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THE REDOUTABLE.

THE central battery and barbette ship Redoutable, illustrated this week, forms part of the French Mediterranean squadron, and although launched as early as 1876 is still one of its most powerful ships. Below are some of the principal dimensions and particulars of this ironclad:

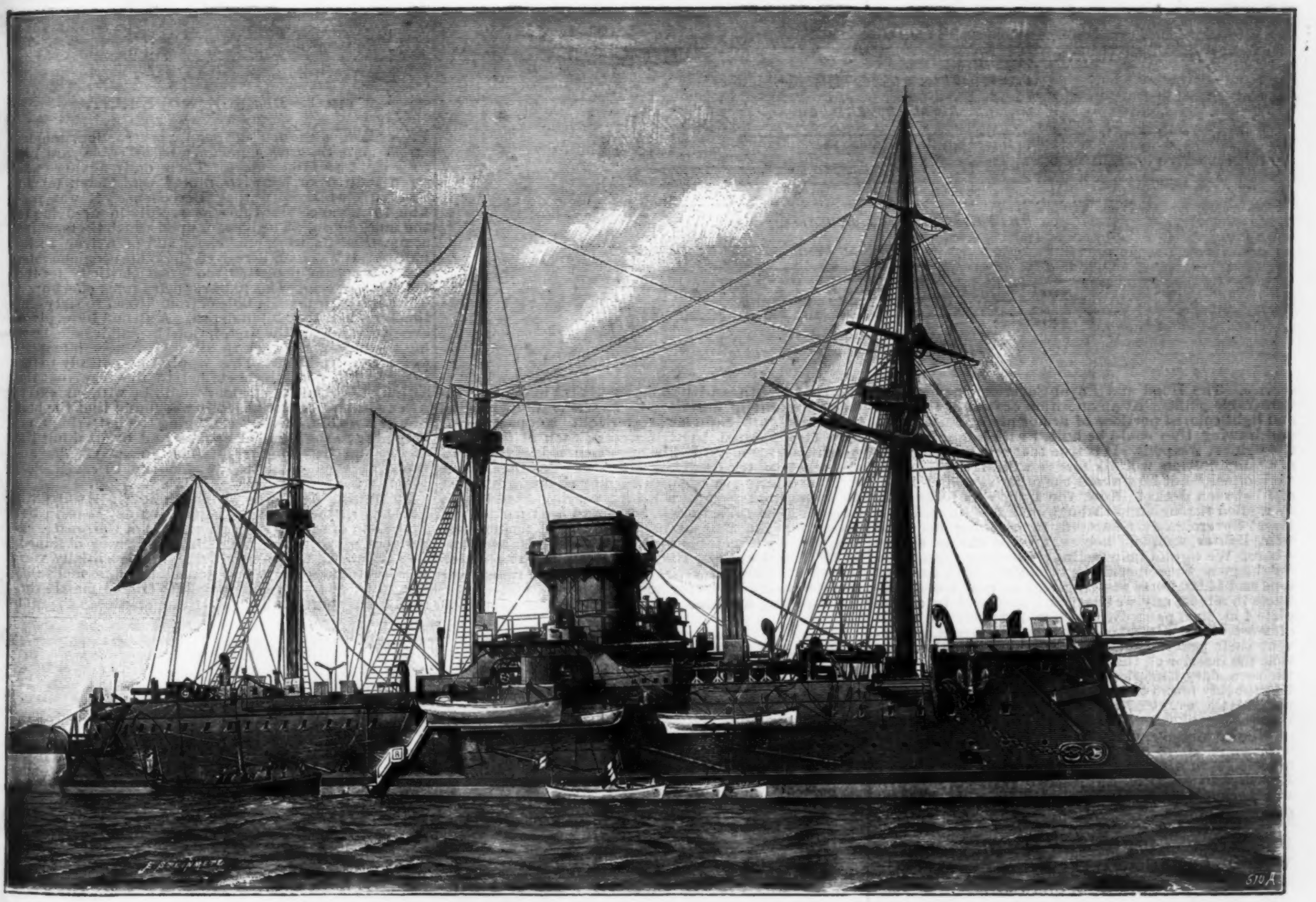
Length	318	ft.	2 in.	
Beam	64	"	8 "	
Draught	25	"	6 "	
Displacement	9200 tons.			
Crew	706 officers and men.			

The Redoutable is built partly of iron and partly of steel and is similar in many respects to the ironclads Devastation and Courbet of the same fleet, although rather smaller. She is completely belted with 14 in. armor, with a 15 in. backing, and has the central battery armored with plates of 9½ in. in thickness.

The engines are two in number, horizontal, and of the compound two cylinder type, developing a horse power of 6,071, which on the trial trip gave a speed of 14·66 knots per hour. Five hundred and ten tons of coal are carried in the bunkers, which at a speed of 10 knots should enable the ship to make a voyage of 2,800 knots. Torpedo defense netting is fitted, and there are three masts with military tops carrying Hotchkiss revolver machine guns.

The offensive power of the ship consists of seven breechloading rifled guns of 27 centimeters (10·63 in.), and weighing 24 tons each, six breechloading rifled guns of 14 centimeters (5·51 in.), and quick-firing and machine guns of the Hotchkiss systems. There are in addition four torpedo discharge tubes, two on each side of the ship. The positions of the guns are as follows: Four of 27 centimeters in the central battery, two on each broadside; three 27 centimeter guns on the upper deck in barbettes, one on each side amidships, and one aft. The 14 centimeter guns are in various positions on the broadsides, and the machine guns are fitted on deck, on the bridges, and in the military tops, four of them also being mounted on what is rather a novelty in naval construction, a gallery running round the outside of the funnel, which was fitted when the ship was under repairs some months ago.

There are three electric light projectors, one forward on the upper deck, one on the bridge just forward of the funnel, and one in the mizzen top.—*Engineering.*



THE FRENCH CENTRAL BATTERY IRONCLAD REDOUTABLE.

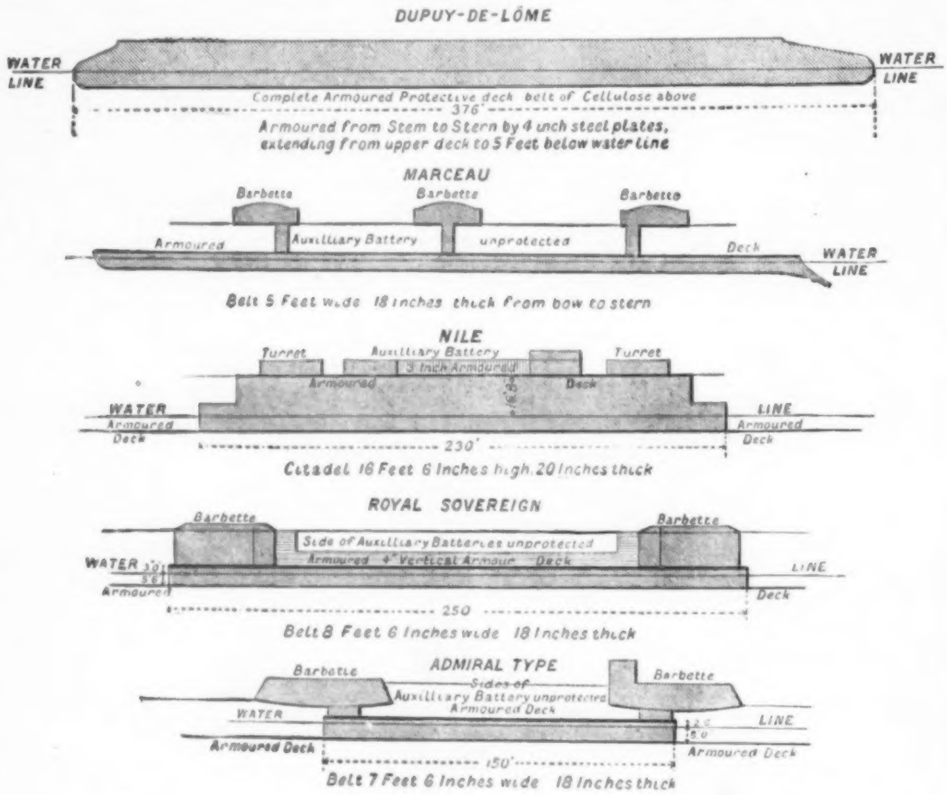
ARMOR PLATING ON BATTLESHIPS: FRANCE AND GREAT BRITAIN.

THE visit of the French squadron under Admiral Gervais to England has revived in many a nautical mind the recollection of that oft-repeated controversy as to the relative advantages of armored belts and citadels. Now that a typical French battleship of the belted class has been brought so prominently to our notice, it may not be considered an inappropriate season to dwell shortly upon the various idiosyncrasies of thought which have produced, in our two nations, types of war vessels differing so materially from each other as to their protective features. In order to facilitate a study of these features, the accompanying sketch has been prepared, which shows at a glance the relative quantities of armored surface that afford protection to the Nile, the Camperdown, the Marceau, the Royal Sovereign, and the Dupuy de Lôme; the first three of these vessels having been actually present at the review on the 21st of August and the two others having been selected as the latest efforts of shipbuilding skill in France and Great Britain. Nothing but the armored surface in each several class is shown, the same scale having been adhered to in all cases.

Two impressions cannot fail to be made upon our minds, both as to French and British armor plate disposition. These two impressions, as regards Great Britain, point to the Royal Sovereign as embodying the idea of two protected stations with a narrow and partial connecting belt; and to the Nile as embodying the idea of a vast and absolutely protected raft. For France, we have the Marceau as representing the wholly belted type with four disconnected but protected stations; and the Dupuy de Lôme, in which the armor plating is thinned out to a substance of only 4 in., so as entirely to cover the sides of the vessel down to 5 ft. below the water line; this thickness of plating being regarded as sufficient to break up upon its surface the dreaded mélinite or guncotton shell, but permitting the passage of armor-piercing projectiles right through from side to side; provision being made to prevent damage from these latter to engines and vitals by means of double-armored decks below, with a belt of cellulose between them. Thus, as we have explained, two prominent ideas are present in the disposition of armor upon the battleships of Great Britain, as well as in that of the battleships of France. But, while in our country these two ideas follow one another in the natural sequence of development, from the Inflexible to the Royal Sovereign, the citadel being gradually extended into two redoubts, and space being left between the redoubts for an auxiliary battery—this latter being, however, singularly placed above the armored belt, and *not within its shelter*—in France, on the other hand, we find the second idea to be a new departure altogether in armored protection, or rather to be a return to the original thought which produced the Gloire and vessels of her class. In point of fact, while we have always clung to the armored citadel, France has discarded the belt altogether, and gone in for speed and light armor, as well as for a much lighter class of armament. Time alone, and the circumstances of actual warfare, can prove which nation has adopted the wisest alternative.

A glance at the engraving will show the striking contrast between the existing service types as to armored surface. The Marceau appears absolutely naked by the side of the solidly armed citadel of the Nile. The contrast between the future types will be, of course, still more striking, for the reasons given in the last paragraph. But while remarking upon the paucity of heavy plating as exhibited in the service French battleships, we would say one word for the angle at which it is placed. The receding sides of the great vessels of France give two very important attributes in their favor. In the first place, a much broader platform at the water line is afforded to secure steadi-

ness of the ship and stable equilibrium, and the angle at which the armor rests is so great as to present a very oblique surface to the impact of projectiles. The trajectory of modern rifled guns is so exceedingly flat that the angle of descent of the shot or shell is practically *nil.* Were the sides of the Royal Sovereign to fall back like those of the Marceau or Magenta, we seriously doubt whether any projectile, however pointed, would effect penetration at all. We conclude, then, that a comparison of the Marceau with the Nile as regards protective features is so incontestably in favor of the latter, that they cannot be classed together for a moment. In speed, moreover, though this is not a point under consideration, the Nile has the advantage. It is impossible, however, to avoid the conviction that the Dupuy de Lôme would be a most powerful and disagreeable enemy for either of the eight great ironclads of Great Britain now building to encounter on



service. The Hood and Royal Sovereign have many vulnerable points. At any position outside of the dark and light colored portions of armor plate indicated in our drawing, they could be hulled with impunity with the lightest weapons. It is true that gun detachments and ammunition will be secure within the internal "crinolines," but how about the other men and *matériel* between decks? Now, the Dupuy de Lôme may be riddled through and through by a 13½ in. shell if a Royal Sovereign ever succeeds in catching her; but from lighter weapons her between decks is almost secure. We cannot help feeling a sneaking admiration for the great French cruising battleship, with her 6,300 tons and 14,000 horse power, giving an easy speed of 20 knots in almost any weather, and protected by a complete 4 in. steel panoply, which will explode the shells of most of our secondary batteries on impact, or prevent their penetration. In fact, there is little doubt that the interior of the Trafalgar, whether as regards the secondary batteries or the unarmored ends, would be probably found to be a safer and pleasanter situation, in the event of action with a Dupuy de Lôme, than either of the naked batteries or the upper works of the Royal Sovereign. This is what Sir E. J. Reed was so anxious to point out at the meeting of naval architects in 1889, when he described the modern British battleship as a "spoiled Trafalgar." There was perhaps some reason in what he said.—*The Engineer.*

DEMOLITION OF ROCKS UNDER WATER WITHOUT EXPLOSIVES—LOBNITZ SYSTEM.*

By Edwin S. Crawley.

The methods of demolishing rocks by the use of explosives are always attended by a certain amount of danger, while at the same time there is always more or less uncertainty in regard to the final result of the operation. Especially is this the case when the work must be carried on without interrupting navigation and in the vicinity of constructions that may receive injury from the explosions.

Such were the conditions imposed in enlarging the Suez Canal in certain parts where the ordinary dredges could not be used.

Mr. Henry Lobnitz, engineer at Renfrew, has contrived a new method of procedure, designed for the purpose of enlarging and deepening the canal in those parts between the Bitter Lakes and Suez, where it runs over a rocky bed. It was necessary to execute the work without interrupting or obstructing traffic on the canal.

The principle of the system consists in producing a shattering of the rock by the action of a heavy mass let fall from a convenient height, and acting like a projectile of artillery upon the wall of a fortress.

From experiments made in the quarry of Craigmiller, near Edinburgh, with a weight of two tons, shod with a steel point, it was found that with a fall of about 5·5 meters (18·04 ft.) there was broken up on an average more than 0·113 cubic meter (0·148 cubic yard) of hard rock per blow. The first blow, delivered 90 centimeters (2 ft. 11½ in.) from the wall face, produced an almost imperceptible rent, a second or a third blow applied at the same place extended this opening often to a length of 1·50 meters (4 ft. 11 in.) and to a depth of from 90 to 120 centimeters (2 ft. 11 in. to 3 ft. 11 in.) The next blow opened the fissure and detached the block of rock.

The application of the same system under water upon an unknown surface would obviously modify the conditions of the experiment. Nevertheless, the results obtained with the "Derocheuse," the first dredging machine constructed upon this principle, have realized the hopes of the inventor.

This dredging machine was launched on the Clyde and reached Port Said in twenty days. It measures 55 meters (180 ft. 5 in.) in length, 12·20 meters (40 ft. 1 in.) in breadth, and 3·65 meters (12 ft.) in depth. Its mean draught of water is 2·75 meters (9 ft. 2½ in.) It is divided into eighteen watertight compartments. Five steel-pointed battering rams, each of four tons weight, are arranged in line upon each side of the chain of buckets of the dredging machine. See Figs. 1 and 2. The battering rams, suspended by chains, are raised by hydraulic power to a height varying from 1·50 to 6 meters (4 ft. 11 in. to 19 ft. 8 in.), and are then let fall upon the rock. The mechanism of the battering rams is carried by a metallic cage which can be moved forward or backward by the aid of steam as the needs of the work require. A series of five battering rams gives from 200 to 300 blows per hour.

A dredging machine combined with the apparatus just described, raises the fragments of rock as they are detached from the bottom. A guide wheel is provided, which supports the chain carrying the buckets, and thus diminishes the stress upon the axles and bearings. With this guide wheel or auxiliary drum there is no difficulty in dredging to a depth of 12 meters (39 ft. 4 in.), while without this accessory it is difficult to attain a depth of 9 meters (29 ft. 6 in.)

A compound engine, with four cylinders of 200 indicated horse power, drives, by means of friction gear, the chain which carries the buckets. If the buckets happen to strike against the rock, the friction gear yields until the excess of resistance has disappeared.

Fig. 3 indicates the manner in which the dredge is operated during the work. It turns alternately about two spuds which are thrust successively into the bottom and about which the dredge describes a series of arcs in a zigzag fashion. These spuds are worked by hydraulic power.

A three ton hand crane is placed upon the bridge for use in making repairs to the chain which carries the buckets. A six ton steam crane is placed upon the top of the cage which supports the hydraulic apparatus for raising the battering rams, thus permitting them to be easily lifted and replaced.

The dredging machine is also furnished with two screws driven by an engine of 300 indicated horse power, as well as with two independent boilers. Two independent series of pumps, with separate connections, feed the hydraulic lifting apparatus, thus permitting repairs to be made when necessary, without interrupting the work. A special machine with three cylinders drives the pumps of the condenser. An accumulator regulates the hydraulic pressure and serves to raise or lower the spuds.

At the end of the Suez Canal next to the Red Sea, the bottom consists of various conglomerates containing gypsum, sandstone and sometimes shells. It was upon a bed of this nature that the machine was first put to work. The mean depth of water, originally 8·25 meters (26 ft. 3 in.), was for a long time sufficient for the traffic of the canal; but as the variations in level of the Red Sea are from 1·8 to 3 meters (5 ft. 11 in. to 9 ft. 10 in.), the depth at the moment of low water is scarcely adequate for the constantly increasing draught of water of the steamers. Attempts were made to attack the rocky surface of the bottom with powerful dredges, but this method was expensive because it necessitated constant repairs to the dredges.

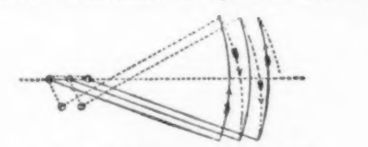


Fig. 3.—DREDGE MOVEMENT.

These last, although of good construction, seldom raised more than 153 cubic meters (200 cubic yards) in from eight to fifteen days. Their daily advance was often only from sixty to ninety centimeters (about 2 to 3 ft.), while with the "Derocheuse" it was possible to advance ten times as rapidly in dredging to the same depth. The bottom upon which the machine commenced its work was clean and of a true rocky nature. It was soon perceived that this conglomerate, rich in gypsum, possessed too great elasticity for the pointed battering rams to have their proper effect upon it. Each blow made a hole of from fifteen to sixty centimeters (6 in. to 2 ft.) in depth. A second blow, given even very near to the first, formed a similar hole, leaving the bed of the rock to all appearances intact between the two holes. This result, due entirely to the special nature of the rock, led to the fear that the action of the battering rams would be without effect. After some experimentation it was found that the best results were obtained by arranging the battering rams very near to the chain of buckets and by working the dredge and battering rams simultaneously. The advance at each oscillation was about 90 centimeters (about 3 ft.)

The results obtained were as follows: At first the quantity extracted varied much from day to day; but at the end of some weeks, on account of the greater experience of the crew, more regularity was obtained. The nature of the conglomerate was essentially variable, sometimes hard and tenacious, like malleable iron, then suddenly changing into friable masses surrounded by portions more elastic and richer in gypsum.

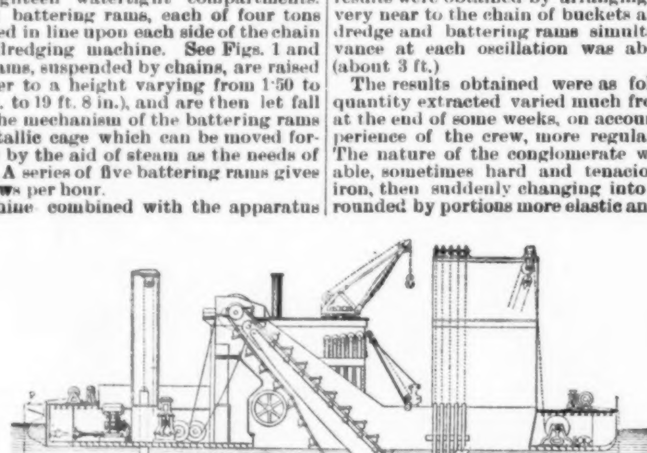


Fig. 1.—LONGITUDINAL SECTION.

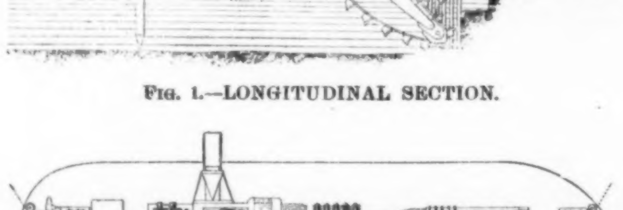


Fig. 2.—PLAN.

During the last five weeks at Port Tewfik, the expense, including the repairs, was 8,850 francs ($1,770.00) for 1,600 cubic meters (2,093 cubic yards) extracted. This would make the cost 5·52 francs per cubic meter, or $0·84 per cubic yard, not including the insurance, the interest and the depreciation of the plant.

After some improvements in details, suggested by practice, the machine was put in operation at Chalouf upon a hard rock, from 1·50 to 3 meters (4 ft. 11 in. to 9 ft. 10 in.) thick. The battering rams were given a fall of 1·80 meters (5 ft. 11 in.) To break the rock into

* Read before the Engineers' Club, Philadelphia. Translated from *Nouvelles Annales de la Construction,* March, 1890.

fragments small enough not to be rejected by the buckets of the dredge, the operations of dredging and of disintegration were carried on separately, permitting the battering rams to work at a greater distance from the wall face. The time consumed in thus pulverizing the rock by repeated blows was naturally found to be increased. It was found more convenient to use only a single row of battering rams. The production was from about seven to eleven cubic meters (9·2 to 14·4 cubic yards) per hour. Toward the close of September, after it had been demonstrated that the "Derocheuse" was capable of accomplishing with celerity and economy the result for which it was designed, it was purchased by the Suez Canal Company.

During the month of September, an experiment, the details of which were carefully noted, extending over a period of sixteen days, gave the following results:

Crew (33 men), 140 hours....	2,012.50 francs	$402.50
Coal, @ 37.50 francs ($7.50) per ton..........................	787·50 francs	157.50
Oil and supplies..............	220·00 francs	44.00
Fresh water, 16 days..........	210.00 francs	42.00
Sundries..................	42.50 francs	8.50
Total expense for removing 764 cubic meters (999·2 cubic yards),	3,272·50 francs	$654.50

Average, 4·28 francs per cubic meter ($0·65 per cubic yard).

This result cannot be taken as a universal basis, because after a year's use there are numerous repairs to make to the plant, which would increase the average net cost. This, besides, does not include the cost of removal of the dredged material, nor the depreciation, the interest and the insurance.

It should be added on the other hand, however, that the warm season was far from being favorable to the energy and perseverance necessary to carry on successfully experiments of this kind. The temperature, even at midnight, was often 38° C. (100·4° F.). Still further, the work was constantly interrupted by the passage of ships through the canal. On an average not more than forty minutes' work to the hour was obtained. Notwithstanding this, there were extracted at Chalouf, on an average, 38·225 cubic meters (50 cubic yards) per day without interrupting navigation. At Port Tewfik, where there was much less inconvenience from the passage of ships, the work was carried on from eight to eleven hours per day and the quantity extracted in this time was generally more than 76 cubic meters (99·4 cubic yards).

In most cases the system could be simplified. The engine which works the dredge could, when not thus employed, be used to drive the pumps. The propelling engine could also be used for the same purpose.

The results obtained at Suez indicate the appreciable advantages arising from the application of this system to the works of ports, rivers and canals, and even to the work of cutting in the construction of roads and railroads.

PROGRESS IN ENGINEERING.

MR. T. FORSTER BROWN, in his address to the Mechanical Science Section of the British Association, said that great progress had been made in mechanical science since the British Association met in the principality of Wales eleven years ago; and some of the results of that progress were exemplified in our locomotives, and marine engineering, and in such works as the Severn Tunnel, the Forth and Tay Bridges, and the Manchester Ship Canal, which was now in progress of construction. In mining, the progress had been slow, and it was a remarkable fact that, with the exception of pumping, the machinery in use in connection with mining operations in Great Britain had not, in regard to economy, advanced so rapidly as had been the case in our manufactures and marine. This was probably due, in metalliferous mining, to the uncertain nature of the mineral deposits not affording any adequate security to adventurers that the increased cost of adopting improved appliances would be reimbursed; while in coal mining, the cheapness of fuel, the large proportion which manual labor bore to the total cost of producing coal, and the necessity for producing large outputs with the simplest appliances, explained the reluctance with which high pressure steam compound engines, and other modes embracing the most modern and approved types of economizing power had been adopted. Metalliferous mining, with the exception of the working of iron ore, was not in a prosperous condition; but in special localities, where the deposits of minerals were rich and profitable, progress had been made within a recent period by the adoption of more economical and efficient machinery, of which the speaker quoted a number of examples. Reference was also made to the rapid strides made in the use of electricity as a motive power, and to the mechanical ventilation of mines by exhaustion of the air.

COAL MINES.

Summarizing the position of mechanical science, as applied to the coal mining industry in this country, Mr. Brown observed that there was a general awakening to the necessity of adopting, in the newer and deeper mines, more economical appliances. It was true it would be impracticable, and probably unwise, to alter much of the existing machinery, but, by the adoption of the best known types of electrical plant, and air compression in our new and deep mines, the consumption of coal per horse power would be reduced, and the extra expense, due to natural causes, of producing minerals from greater depths would be substantially lessened. The consumption of coal at the collieries of Great Britain alone probably exceeded 10,000,000 tons per annum, and the consumption per horse power was probably not less than 6 lb. of coal, and it was not unreasonable to assume that, by the adoption of more efficient machinery than was at present in general use, at least one-half of the coal consumed could be saved. There was, therefore, in the mines of Great Britain alone a wide and lucrative field for the inventive ingenuity of mechanical engineers in economizing fuel, and especially in the successful application of new methods for dealing with underground haulage, in the inner workings of our collieries, more especially in South Wales, where the number of horses still employed was very large.

STEAM TRAMS AND ELECTRIC TRAMS.

Considerable progress had within recent years been made in the mechanical appliances intended to replace horses on our public tram lines. The steam engine now in use in some of our towns had its drawbacks as well as its good qualities, as also had the endless rope haulage, and in the case of the latter system, anxiety must be felt when the ropes showed signs of wear. The electrically driven trams appeared to work well. He had not, however, seen any published data bearing on the relative cost per mile of these several systems, and this information, when obtained, would be of interest. At the present time, he understood, exhaustive trials were being made with an ammonia gas engine, which, it was anticipated, would prove both more economical and efficient than horses for tram roads. The gas was said to be produced from the pure ammonia, obtained by distillation from commercial ammonia, and was given off at a pressure varying from 100 to 150 lb. per square inch. This ammonia was used in specially constructed engines, and was then exhausted into a tank containing water, which brought it back into its original form of commercial ammonia, ready for redistillation, and, it was stated, with a comparatively small loss.

IMPROVED CHANGEABLE SPEED GEARING.

THIS is the invention of Lawrence Heath, of Macedon, N. Y., and relates to that class of changeable speed gearing in which a center pinion driven at a constant rate of speed drives directly and at different rates of speed a series of pinions mounted in a surrounding revoluble case or shell, so that by turning

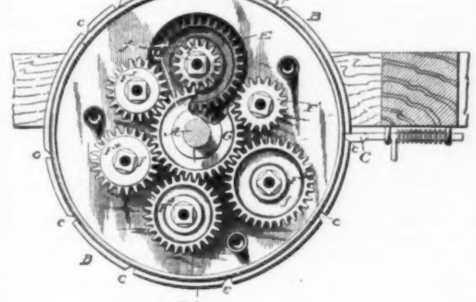


FIG. 1.

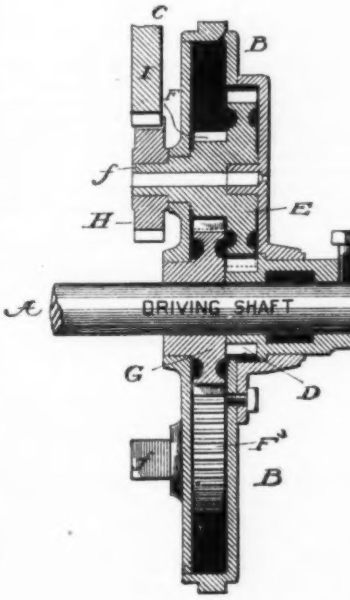


FIG. 2.

the shell one or another of the secondary pinions may be brought into operative relation to the parts to be driven therefrom.

The aim of my invention is to so modify this system of gearing that the secondary pinions may receive a very slow motion in relation to that of the primary driving shaft, whereby the gearing is the better adapted for the driving of the fertilizer-distributers of grain drills from the main axle, and for other special uses.

Fig. 1 is a side elevation. Fig. 2 is a vertical cross section.

A represents the main driving shaft or axle, driven constantly and at a uniform speed, and B is the pinion-supporting case or shell, mounted loosely on and revoluble around the axle, but held normally at rest by means of a locking bolt, C, or other suitable locking device adapted to enter notches, c, in the shell.

D is the primary driving pinion, fixed firmly to the axle and constantly engaging the pinion, E, mounted on a stud in the shell. The pinion, E, is formed integral with or firmly secured to the smaller secondary pinion, F, which in turn constantly engages and drives the center pinion, G, mounted to turn loosely on the axle within the shell, so that it is turned in the same direction as the axle, but at a slower speed.

F, F_2, F_3, F_4, etc., represent additional secondary pinions grouped around the center pinion, mounted on studs in the shell, and made of different diameters, so that they are driven by the center pinion at different speeds. Each of the secondary pinions is formed with a neck or journal, *f*, projected out through the side of the shell, so that the external pinion, H, may be applied to any one of the necks at will in order to communicate motion thence to the gear, I, which occupies a fixed position, and from which the fertilizer or other mechanism is driven.

In order to drive the gear, I, at one speed or another, as may be demanded, it is only necessary to apply the pinion, H, to the neck of that secondary pinion which is turning at the appropriate speed and then turn the shell bodily around the axle until the external pinion is carried into engagement with gear I, when the shell is again locked fast. The axle communicates motion through D, E, and F to the center pinion, which in turn drives all the secondary pinions except F. If the external pinion is applied to F, it will receive motion directly therefrom; but if applied to either of the secondary pinions, it will receive motion through or by way of the center pinion. It will be seen that all the pinions are sustained and protected within the shell.

The essence of the invention lies in the introduction of the pinions D and E between the axle and the series of secondary pinions to reduce the speed.

ELECTRICAL STANDARDS.

Nature states that the Queen's Printers are now issuing the Report (dated July 23, 1891) to the President of the Board of Trade, of the Committee appointed to consider the question of constructing standards for the measurement of electricity. The committee included Mr. Courtenay Boyle, C.B., Major P. Cardew, R.E., Mr. E. Graves, Mr. W. H. Preece, F.R.S., Sir W. Thomson, F.R.S., Lord Rayleigh, F.R.S., Prof. G. Carey Foster, F.R.S., Mr. R. T. Glazebrook, F.R.S., Dr. John Hopkinson, F.R.S., Prof. W. E. Ayrton, F.R.S.

In response to an invitation, the following gentlemen attended and gave evidence: On behalf of the Association of Chambers of Commerce, Mr. Thomas Parker and Mr. Hugh Erat Harrison; on behalf of the London Council, Prof. Silvanus Thompson; on behalf of the London Chamber of Commerce, Mr. R. E. Crompton. The Committee were indebted to Dr. J. A. Fleming and Dr. A. Muirhead for valuable information and assistance; and they state that they had the advantage of the experience and advice of Mr. H. J. Chaney, the Superintendent of Weights and Measures. The Secretary to the Committee was Sir T. W. P. Blomefield, Bart.

The following are the resolutions of the Committee:

Resolutions.

(1) That it is desirable that new denominations of standards for the measurement of electricity should be made and approved by Her Majesty in Council as Board of Trade standards.

(2) That the magnitudes of these standards should be determined on the electro-magnetic system of measurement with reference to the centimeter as unit of length, the gramme as unit of mass, and the second as unit of time, and that by the terms centimeter and gramme are meant the standards of those denominations deposited with the Board of Trade.

(3) That the standard of electrical resistance should be denominated the ohm, and should have the value 1,000,000,000 in terms of the centimeter and second.

(4) That the resistance offered to an unvarying electric current by a column of mercury of a constant cross sectional area of 1 square millimeter, and of a length of 106.3 centimeters at the temperature of melting ice may be adopted as 1 ohm.

(5) That the value of the standard of resistance constructed by a committee of the British Association for the Advancement of Science in the years 1863 and 1864, and known as the British Association unit, may be taken as 0·9866 of the ohm.

(6) That a material standard, constructed in solid metal, and verified by comparison with the British Association unit, should be adopted as the standard ohm.

(7) That for the purpose of replacing the standard, if lost, destroyed, or damaged, and for ordinary use, a limited number of copies should be constructed, which should be periodically compared with the standard ohm and with the British Association unit.

(8) That resistances constructed in solid metal should be adopted as Board of Trade standards for multiples and sub-multiples of the ohm.

(9) That the standard of electrical current should be denominated the ampere, and should have the value one-tenth (0·1) in terms of the centimeter, gramme, and second.

(10) That an unvarying current which, when passed through a solution of nitrate of silver in water, in accordance with the specification attached to this report, deposits silver at the rate of 0·001118 of a gramme per second, may be taken as a current of 1 ampere.

(11) That an alternating current of 1 ampere shall mean a current such that the square root of the time-average of the square of its strength at each instant in amperes is unity.

(12) That instruments constructed on the principle of the balance, in which, by the proper disposition of the conductors, forces of attraction and repulsion are produced, which depend upon the amount of current passing, and are balanced by known weights, should be adopted as the Board of Trade standards for the measurement of current, whether unvarying or alternating.

(13) That the standard of electrical pressure should be denominated the volt, being the pressure which, if steadily applied to a conductor whose resistance is 1 ohm, will produce a current of 1 ampere.

(14) That the electrical pressure at a temperature of 62° F. between the poles or electrodes of the voltaic cell known as Clark's cell may be taken as not differing from a pressure of 1·433 volts by more than an amount which will be determined by a sub-committee appointed to investigate the question, who will prepare a specification for the construction and use of the cell.

(15) That an alternating pressure of 1 volt shall mean a pressure such that the square root of the time average of the square of its value at each instant in volts is unity.

(16) That instruments constructed on the principle of Sir W. Thomson's quadrant electrometer used idiostatically, and for high pressure instruments on the principle of the balance, electrostatic forces being balanced against a known weight, should be adopted as Board of Trade standards for the measurement of pressure, whether unvarying or alternating.

We have adopted the system of electrical units originally defined by the British Association for the Advancement of Science, and we have found in its recent researches, as well as in the deliberations of the International Congress on Electrical Units, held in Paris, valuable guidance for determining the exact magnitudes of the several units of electrical measurement, as well as for the verification of the material standards.

We have stated the relation between the proposed standard ohm and the unit of resistance originally determined by the British Association, and have also stated its relation to the mercurial standard adopted by the International Conference.

We find that considerations of practical importance make it undesirable to adopt a mercurial standard; we have, therefore, preferred to adopt a material standard constructed in solid metal.

It appears to us to be necessary that in transactions between buyer and seller, a legal character should henceforth be assigned to the units of electrical measurement now suggested; and with this view, that the issue of an Order in Council should be recommended, under the Weights and Measures Act, in the form annexed to this report.

Specification referred to in Resolution 10.

In the following specification the term silver voltameter means the arrangement of apparatus by means of which an electric current is passed through a solution of nitrate of silver in water. The silver voltameter measures the total electrical quantity which has passed during the time of the experiment, and by noting this time the time average of the current, or if the current has been kept constant, the current itself, can be deduced.

In employing the silver voltameter to measure currents of about 1 ampere, the following arrangements should be adopted. The kathode on which the silver is to be deposited should take the form of a platinum bowl not less than 10 cm. in diameter, and from 4 to 5 cm. in depth.

The anode should be a plate of pure silver some 30 square cm. in area and 2 or 3 millimeters in thickness.

This is supported horizontally in the liquid near the top of the solution by a platinum wire passed through holes in the plate at opposite corners. To prevent the disintegrated silver which is formed on the anode from falling on to the kathode, the anode should be wrapped round with pure filter paper, secured at the back with sealing wax.

The liquid should consist of a neutral solution of pure silver nitrate, containing about 15 parts by weight of the nitrate to 85 parts of water.

The resistance of the voltameter changes somewhat as the current passes. To prevent these changes having too great an effect on the current, some resistance besides that of the voltameter should be inserted in the circuit. The total metallic resistance of the circuit should not be less than 10 ohms.

Method of making a Measurement.—The platinum bowl is washed with nitric acid and distilled water, dried by heat, and then left to cool in a desiccator. When thoroughly dry, it is weighed carefully.

It is nearly filled with the solution, and connected to the rest of the circuit by being placed on a clean copper support, to which a binding screw is attached. This copper support must be insulated.

The anode is then immersed in the solution, so as to be well covered by it, and supported in that position; the connections to the rest of the circuit are made.

Contact is made at the key, noting the time of contact. The current is allowed to pass for not less than half an hour, and the time at which contact is broken is observed. Care must be taken that the clock used is keeping correct time during this interval.

The solution is now removed from the bowl, and the deposit is washed with distilled water and left to soak for at least six hours. It is then rinsed successively with distilled water and absolute alcohol, and dried in a hot-air bath at a temperature of about 160° C. After cooling in a desiccator, it is weighed again. The gain in weight gives the silver deposited.

To find the current in amperes, this weight, expressed in grammes, must be divided by the number of seconds during which the current has been passed, and by 0·001118.

The result will be the time average of the current, if during the interval the current has varied.

In determining by this method the constant of an instrument the current should be kept as nearly constant as possible, and the readings of the instrument taken at frequent observed intervals of time. These observations give a curve from which the reading corresponding to the mean current (time average of the current) can be found. The current, as calculated by the voltameter, corresponds to this reading.

THE TWO OR THREE PHASE ALTERNATING CURRENT SYSTEMS.

By CARL HERING.

THE occasion of the transmission of power from Lauffen to Frankfort has brought to the notice of the profession more than ever before the two or three phase alternating current systems, described as early as 1887–88 by various electricians, among whom are Tesla, Bradley, Haselwander and others. As to who first invented it, we have nothing to say here, but though known for some years it has not until quite recently been of any great importance in practice.

Within the last few years, however, Mr. M. Von Dolivo-Dobrowolsky, electrical engineer of the Allgemeine Elektricitats Gesellschaft, of Berlin, has occupied himself with these currents. His success with motors run with such currents was the origin of the present great transmission of power exhibit at Frankfort, the greatest transmission ever attempted. His investigation in this new sphere, and his ability to master the subject from a theoretical or mathematical standpoint, has led him to find the objections, the theoretically best conditions, etc. This, together with his ingenuity, has led him to devise an entirely new and very ingenious modification, which will no doubt have a very great effect on the development of alternating current motors.

It is doubtless well known that if, as in Fig. 1, a Gramme ring armature is connected to leads at four points as shown and a magnet is revolved inside of it (or if the ring is revolved in a magnetic field and the current led off by contact rings instead of a commutator), there will be two alternating currents generated, which will differ from each other in their phases only. When one is at a maximum the other is zero. When such a double current is sent into a similarly constructed motor it will produce or generate what might be called a rotary field, which is shown diagrammatically in the six successive positions in Fig. 2. The winding here is slightly different, but it amounts to the same thing as far as we are concerned at present. This is what Mr. Dobrowolsky calls an "elementary" or "simply" rotary current, as used in the Tesla motors. A similar system, but having three different currents instead of two, is the one used in the Lauffen transmission experiment referred to above.

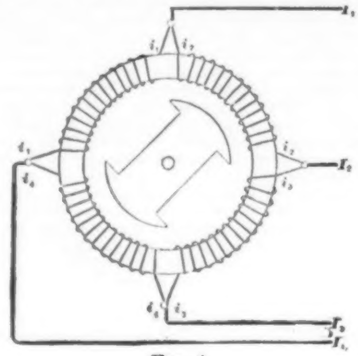


FIG. 1.

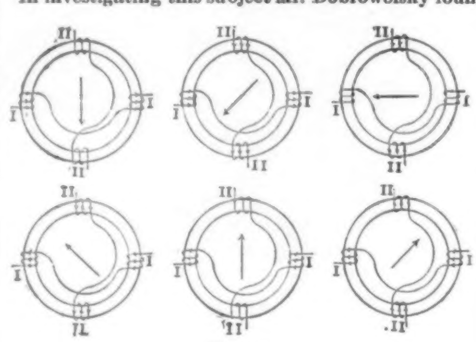


FIG. 2.

In investigating this subject Mr. Dobrowolsky found that the best theoretical indications for such a system would be a large number of circuits instead of only two or three, each differing from the next one by only a small portion of a wave length; the larger their number the better theoretically. The reason is that with a few currents the resulting magnetism generated in the motor by these currents will pulsate considerably, as shown in Fig. 3, in which the two full lines show the currents differing by 90 degrees. The dotted line above these shows how much the resulting magnetism will pulsate. With two such currents this variation in magnetism will be about 40 degrees above its lowest value. Now, such a variation in the field is undesirable, as it produces objectionable induction effects, and it has the evil effect of interfering with the starting of the motor loaded, besides affecting the torque considerably if the speed should fail slightly below that for synchronism. A perfect motor should not have these faults, and it is designed to obviate them by striving to obtain a revolving field in which the magnetism is as nearly constant as possible.

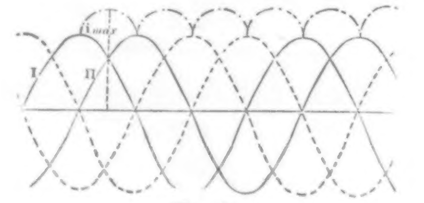


FIG. 3.

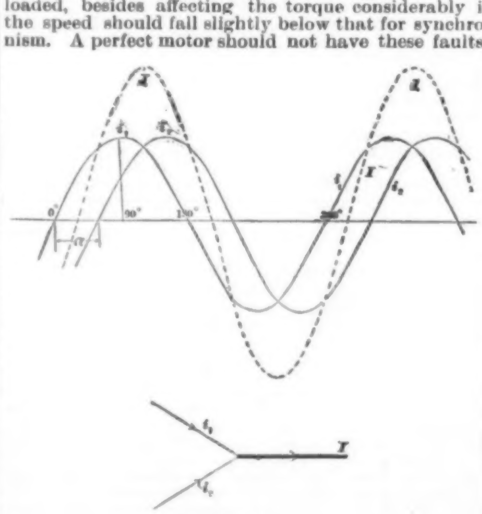


FIG. 4.

If there are two currents differing by 90 degrees, this variation of the magnetism will be about 40 per cent.; with three currents differing 60 degrees, about 14 per cent.; with six currents differing 30 degrees it will be only about 4 per cent., and so on. It will be seen, therefore, that by doubling the three-phase system the pulsations are already very greatly reduced. But this would require six wires, while the three-phase system requires only three wires (as each of the three leads can readily be shown to serve as a return lead for the other two in parallel). It is to combine the advantages of both that he designed the following very ingenious system. By this system he can obtain as small a difference of phase as desired, without increasing the number of wires above three, a statement which might at first seem paradoxical.

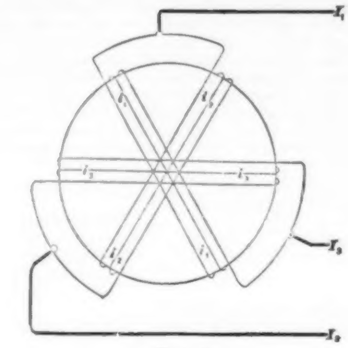


FIG. 5.

Before explaining this ingenious system, it might be well to call attention to a parallel case to the above in continuous current machines and motors. The first dynamos were constructed with two commutator bars. They were soon found to work much better with four, and finally still better as the number of commutator bars (or coils) was increased, up to a practical limit. Just as the pulsations in the continuous current dynamos were detrimental to proper working, so are these pulsations in few-phased alternating current motors, though the objections manifest themselves in different ways—in the continuous current motors as sparking and in the alternating current motors as detrimental inductive effects.

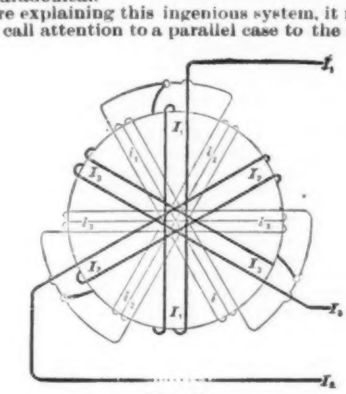


FIG. 6.

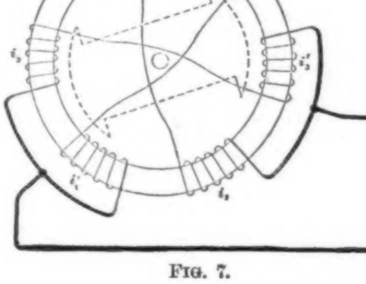


FIG. 7.

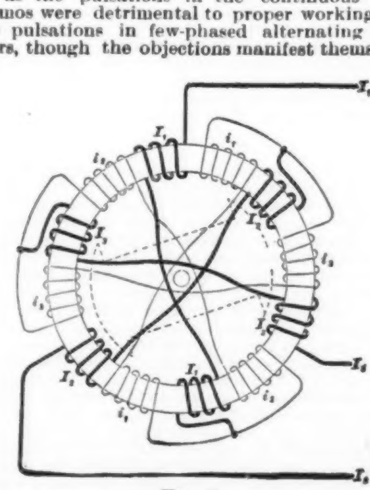


FIG. 8.

The underlying principle of this new system may be seen best in Figs. 4, 5, 6, 7 and 8. In Fig. 4 are shown two currents, I_1 and I_2, which differ from each other

by an angle, D. Suppose these two currents to be any neighboring currents in a simple rotary current system. Now, if these two currents be united into one, as shown in the lower part of the figure, the resulting current, I, will be about as shown by the dotted line; that is, it will lie between the other two and at its maximum point, and for a difference of phases equal

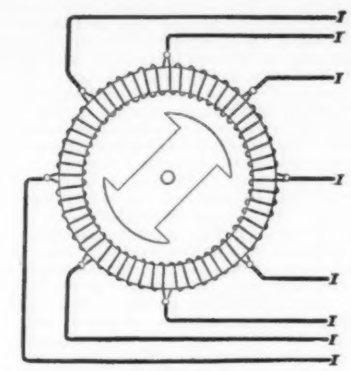


Fig. 9.

to 90 degrees it will be about 1·4 times as great as the maximum of either of the others; the important feature is that the phase of this current is midway between that of the other two. Fig. 5 shows the winding of a cylinder armature and Fig. 7 that of a Gramme armature for a simple three-phase current with three leads,

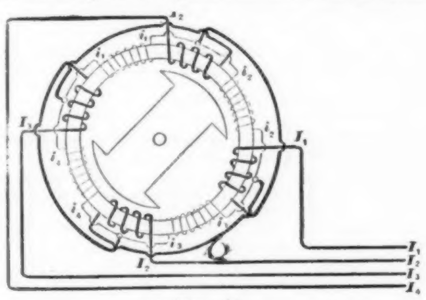


Fig. 10.

with which system we assume that the reader is familiar.

The two figures, 4 and 5 (or 7), correspond with each other in so far as the currents in the three leads, shown in heavy lines, have a phase between those of the two which compose them. Referring now to Fig. 6 (or 8), which is precisely like Fig. 5 (or 7), except that it

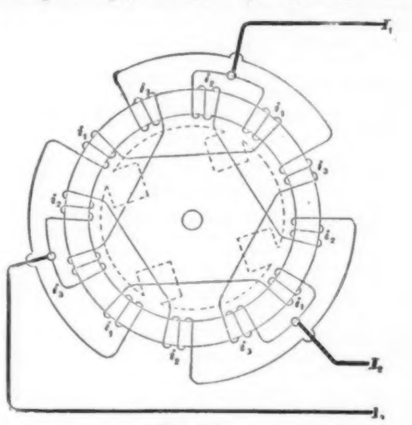


Fig. 11.

has an additional winding shown in heavy lines, it will be seen that each of the three leads, shown in heavy lines, is wound around the armature before leaving it, forming an additional coil lying *between* the two coils with which it is in series. The phase of the heavy line currents was shown in Fig. 4 to lie between the other two. Therefore, in the armature in Fig. 6 (or

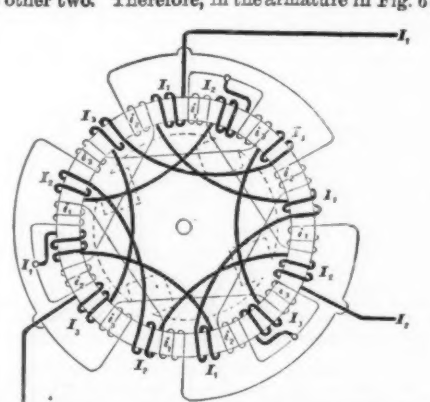


Fig. 12.

8) there will be six phases, while in Fig. 5 there are only three, the number of leads (three) remaining the same as before. This is the fundamental principle of this ingenious invention. To have six phases in Fig. 5 would require six leads, but in Fig. 6 precisely the same result is obtained with only three leads. In the same way the three leads in Fig. 6 might again be combined and passed around the armature again, and so on forming still more phases, without increasing the number of leads. Figs. 7 and 8 compound with 5 and 6 and show the same system for a Gramme ring instead of a cylinder armature.

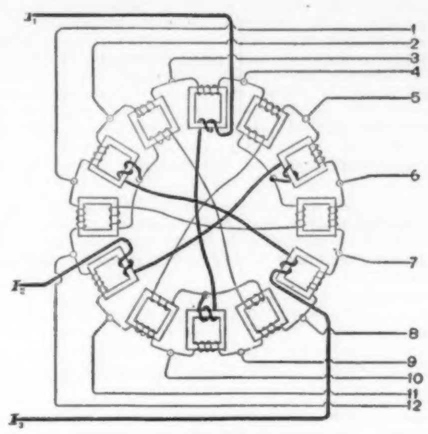


Fig. 13.

As was stated in the early part of this description, the main object in a rotary current motor is to have a magnetic field which is as nearly constant in intensity as possible, and which changes only its position, that is, its axis. But in Fig. 4 it was shown that the current I (in dotted lines) is greater than the others (about as 1·4 to 1 for a phase difference of 90 degrees). If therefore the coils in Fig. 6 or 8 were all alike, the magnetism generated by the heavy line coils would be greater than that generated by the others, and would therefore produce very undesirable pulsations in the magnetic fields; but as the magnetism depends on the ampere turns, it is necessary merely to have correspondingly fewer turns on these coils, as compared with the others. This is shown diagrammatically in Figs. 6 and 8, in which the heavy line coils have less windings than the others. In practice it is not always possible to obtain the exact ratio of 1 to 1·4, for in-

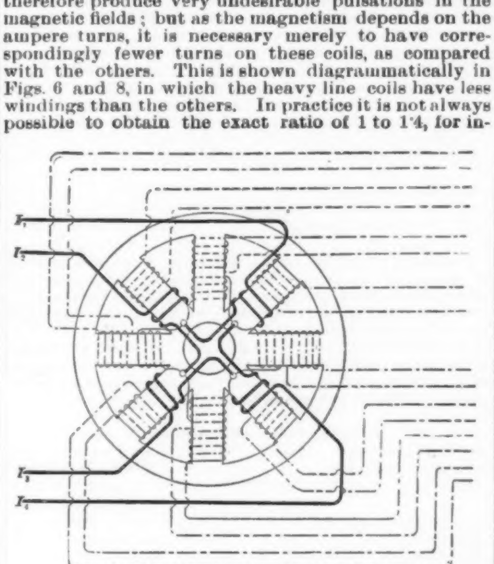


Fig. 14.

stance, but even if this ratio is obtained only approximately, it nevertheless reduces the pulsations very materially below what they would be with half the number of phases. It is therefore not necessary in practice to have more than an approximation to the exact conditions.

Fig. 9 shows a multiple phase armature having double the number of phases as Fig. 1, and would according to the old system, therefore, require eight leads. Fig. 10 shows the new system with the same number of phases as in Fig. 9, but requiring only four leads instead of eight. Figs. 11 and 12 correspond with Figs. 7 and 8 and show the windings for a multipolar motor in the two systems.

These figures show how a motor may be wound so as to be a multiple phase motor, although the current entering the motor is a simple, elementary three or two phase current, which can be transformed by means of a simple three or two phase current transformer, before entering the motor, such transformers as are used

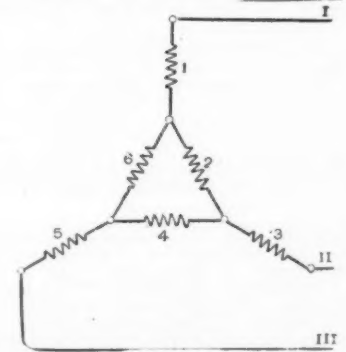


Fig. 15.

at present in the Lauffen-Frankfort transmission. But the same principle as that for the motor may also be applied to transformers themselves, as shown in Figs. 13 and 14. Fig. 13 shows a set of transformers which are fed by a simple three-phase current shown in heavy lines, and which gives in its secondary circuit a multiple phase rotary current. The connections for the primary circuit of a transformer with six coils are shown diagrammatically in Fig. 15, the numbers 1 to 6 representing the succession of the phases. Fig. 14 shows a transformer for a two-phase current with four leads, transforming into a multiple phase current of 16 leads. The transformer in this figure is a single "interlocked" transformer in which the fields are magnetically connected and not independent of each other as in Fig. 13. This has advantages in the regulation of currents, which do not exist in Fig. 13, but which need not be entered into here. The transformers used in the Lauffen-Frankfort transmission are similar, magnetically, to Fig. 14, only that they are for a simple three-phase current in both primary and secondary circuits. Attention is also called to the difference in the connections of secondary circuits in Figs. 13 and 14; in the former they are connected in a closed circuit similarly to an ordinary closed circuit armature, while in Fig. 14 they are independent as far as the currents themselves are concerned, though magnetically their cores are connected. It is not the intention to enter into a discussion of the relative values of these various connections, but merely to draw attention to the wide range of the number of combinations which this system admits of.—*Electrical World.*

THE LONDON PARIS TELEPHONE.*

By W. H. Preece, F.R.S.

1. I have already on two occasions, at Newcastle and at Leeds, brought this subject before Section G, and have given the details of the length and construction of the proposed circuit.

I have now to report not only that the line has been constructed and opened to the public, but that its success, telephonic and commercial, has exceeded the most sanguine anticipations. Speech has been maintained with perfect clearness and accuracy. The line has proved to be much better than it ought to have been, and the purpose of this paper is to show the reason why.

The lengths of the different sections of the circuit are as follows:

London to St. Margaret's Bay.....	84·5 miles.
St. Margaret's Bay to Sangatte (cable)........................	23·0 "
Sangatte to Paris.........	199·0 "
Paris underground..............	4·8 "
Total.........................	311·3 "

The resistances are as follows:

Paris underground......	70 ohms.
French line....................... ...	294 "
Cable...........	143 "
English line.............	183 "
Total (R)........	693 "

The capacities are as follows:

Paris underground.........	0·43 microfarads.
French line.................	3·33 "
Cable........................	5·52 "
English line	1·32 "
Total (K)...........	10·62 "

$$693 \times 10{\cdot}62 = 7{,}359 = K\,R$$

a product which indicates that speech should be very good.

2. *Trials of Apparatus.*—The preliminary trials were made during the month of March between the chief telegraph offices of the two capitals, and the following microphone transmitters were compared:

Ader	Pencil form.
Berliner	Granular form.
D'Arsonval...... ...	Pencil "
De Jongh...........	" "
Gower Bell.........	" "
Post office switch instrument.....	Granules and lamp filaments.
Roulez...............	Lamp filaments.
Turnbull	Pencil form.
Western Electric....	Granular.

The receivers consisted of the latest form of double-pole Bell telephones with some Ader and D'Arsonval receivers for comparison. After repeated trials it was finally decided that the Ader, D'Arsonval, Gower-Bell (with double-pole receivers instead of tubes), Roulez, and Western Electric were the best, and were approximately equal.

These instruments were, therefore, selected for the further experiments, which consisted of using local extensions in Paris and London. The wires were in the first instance extended at the Paris end to the Observatory through an exchange at the Avenue des Gobelines. The length of this local line is 7 kms. The wires are guttapercha-covered, placed underground, and not suitable for giving the best results.

The results were, however, fairly satisfactory. The wires were extended to the Treasury in London by means of the ordinary underground system. The distance is about two miles, and although the volume of sound and clearness of articulation were perceptibly reduced by these additions to the circuit, conversation was quite practicable.

Further trials were also made from the Avenue des Gobelines on underground wires of five kilometers long, and also with some renters in Paris with fairly satisfactory results. The selected telephones were equally efficient in all cases, which proves that to maintain easy conversation when the trunk wires are extended to local points it is only necessary that the local lines shall be of a standard not lower than that of the trunk line. The experiments also confirm the conclusion that long-distance speaking is solely a question of the circuit and its environments, and not one of apparatus. The instruments finally selected for actual work were Gower-Bell for London and Roulez for Paris.

3. The results are certainly most satisfactory. There is no circuit in or out of London on which speech is more perfect than it is between London and Paris. In

* Paper read before the British Association.—*Elec. Engineer.*

fact, it is better than I anticipated, and better than calculation led me to expect. Speech has been possible not only to Paris but through Paris to Bruxelles, and even, with difficulty, through Paris to Marseilles, a distance of over 900 miles. The wires between Paris and Marseilles are massive copper wires specially erected for telephone business between those important places.

4. *Business Done.*—The charge for a conversation between London and Paris is 8 s. for three minutes' complete use of the wire. The demand for the wire is very considerable. The average number of talks per day, exclusive of Sunday, is 86. The maximum has been 108. We have had as many as 19 per hour—the average is 15 during the busy hours of the day. As an instance of what can be done, 150 words per minute have been dictated in Paris and transcribed in London by shorthand writing. Thus in three minutes 450 words were recorded, which at 8 s. cost five words for a penny.

5. *Difficulties.*—The difficulties met with in long-distance speaking are several, and they may be divided into (*a*) those due to external disturbances and (*b*) those due to internal opposition.

(*a*.) Every current rising and falling in the neighborhood of a telephone line within a region, say, of 100 yards, whether the wire conveying it be underground or overground, induces in the telephone circuit another current, producing in the telephone a sound which disturbs speech, and if the neighboring wires are numerous and busy, as they are on our roads and railways, these sounds became confusing, noisy, and ultimately entirely preventive of speech. This disturbance is, however, completely removed by forming the telephone circuit of two wires placed as near to each other as possible, and twisted around each other without touching, so as to maintain the mean average distance of each wire from surrounding conductors the same everywhere. Thus similar currents are induced in each of the two wires, but being opposite in direction, as far as the circuit is concerned, they neutralize each other, and the circuit, therefore, becomes quite silent.

In England we make the two wires revolve completely round each other in every four poles, but in France it is done in every six poles. The reason for the change is the fact that in the English plan the actual crossing of the wires takes place in the span between the poles, while in the French plan it takes place at the poles. This is supposed to reduce the liability of the wires to be thrown into contact with each other by the wind, but, on the other hand, it diminishes the geometrical symmetry of the wires—so very essential to insure silence. As a matter of fact, contacts do not occur on well constructed lines, and I think our English wires, being more symmetrical, are freer from external disturbance than those in France.

(*b*.) The internal opposition arises from the resistance, R, the capacity, K, and the electromagnetic inertia, L, of the circuit. A current of electricity takes time to rise to its maximum strength and time to fall back again to zero. Every circuit has what is called its time constant, *t*, Fig. 1, which regulates the number of current waves which can be transmitted through it per second. This is the time the current takes to rise from zero to its working maximum, and the time it takes to fall from this maximum to zero again, shown by the shaded portions of the figure; the duration of the working current being immaterial, and shown by the unshaded portion.

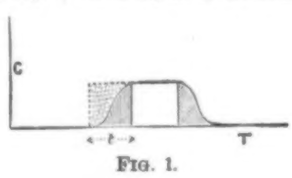


FIG. 1.

The most rapid form of quick telegraphy requires about 150 currents per second, currents each of which must rise and fall in $\frac{1}{150}$ of a second, but for ordinary telephone speaking we must have about 1,500 currents per second, or the time which each current rises from zero to its maximum intensity must not exceed $\frac{1}{3000}$ part of a second. The time constant of a telephone circuit should therefore not be less than 0·0003 second.

Resistance alone does not affect the time constant. It diminishes the intensity or strength of the currents only; but resistance, combined with electromagnetic inertia and with capacity, has a serious retarding effect on the rate of rise and fall of the currents. They increase the time constant and introduce a slowness which may be called retardance, for they diminish the rate at which currents can be transmitted. Now the retardance due to electromagnetic inertia increases directly with the amount of electromagnetic inertia present, but it diminishes with the amount of resistance of the conductor. It is expressed by the ratio $\frac{L}{R}$ while that due to capacity increases directly, both with the capacity and with the resistance, and it is expressed by the product, K R. The whole retardance, and, therefore, the speed of working the circuit or the clearness of speech, is given by the equation

$$\frac{L}{R} + K\,R = t$$

or

$$L + K\,R^2 = R\,t$$

Now in telegraphy we are not able altogether to eliminate L, but we can counteract it, and if we can make $R\,t = 0$, then

$$L = -K\,R^2$$

which is the principle of the shunted condenser that has been introduced with such signal success in our post office service, and has virtually doubled the carrying capacity of our wires.

If, in the above equation, we make $L = 0$

$$K\,R = t$$

This is done in telephony, and hence we obtain the law of retardance, or the law by which we can calculate the distance to which speech is possible. All my calculations for the London and Paris line were based on this law, which experience has shown it to be true.

How is electromagnetic inertia practically eliminated? First, by the use of two massive copper wires, and secondly by symmetrically revolving them around each other. Now L depends on the geometry of the circuit, that is, on the relative form and position of the different parts of the circuit, which is invariable for the same circuit, and is represented by a coefficient, λ. It depends also on the magnetic qualities of the conductors employed and of the space embraced by the circuit. This specific magnetic capacity is a variable quantity, and is indicated by μ for the conductor and by μ_0 for air. It depends also on the rate at which currents rise and fall, and this is indicated by the differential coefficient $\frac{d\,C}{d\,t}$ It depends finally on the number of lines of force due to its own current which cut the conductor in the proper direction; this is indicated by β. Combining these together we can represent the electromagnetic inertia of a metallic telephone circuit as

$$L = \lambda\,(\mu + \mu_0)\frac{d\,C}{d\,t} \times \beta$$

Now, $\lambda = 2 \log \frac{d^2}{a^2}$ Hence the smaller we make the distance, *d*, between the wires, and the greater we make their diameter, *a*, the smaller becomes λ. It is customary to call the value of μ for air, and copper, 1, but this is purely artificial and certainly not true. It must be very much less than one in every medium, excepting the magnetic metals, so much so that in copper it may be neglected altogether, while in the air it does not matter what it is, for by the method of twisting one conductor round the other, the magnetization of the air space by the one current of the circuit rotating in one direction is exactly neutralized by that of the other element of the circuit rotating in the opposite direction.

Now, β, in two parallel conductors conveying currents of the same sense, that is flowing in the same direction, is retarding, Fig. 2, and is therefore a positive quantity, but when the currents flow in opposite directions, as in a metallic loop, Fig. 3, they tend to assist each other and are of a negative character. Hence in a metallic telephone circuit we may neglect L *in toto* as I have done.

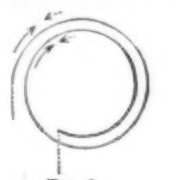


FIG. 2.

I have never yet succeeded in tracing any evidence of electromagnetic inertia in long single copper wires, while in iron wires the value of L may certainly be taken at 0·005 henry per mile.

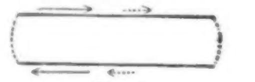


FIG. 3.

In short metallic circuits, say of lengths up to 100 miles, this negative quantity does not appear, but in the Paris-London circuit this helpful mutual action of opposite currents comes on in a peculiar way. The presence of the cable introduces a large capacity practically in the center of the circuit. The result is that we have in each branch of the circuit between the transmitter, say, at London and the cable at Dover, extra currents at the commencement of the operation, which, flowing in opposite directions, mutually react on each other, and practically prepare the way for the working currents. The presence of these currents is proved by the fact that when the cable is disconnected at Calais, as shown in Fig. 5, and telephones are inserted in series, as shown at D and D', speech is as perfect between London and St. Margaret's Bay as if the wires were connected across, or as if the circuit were through to Paris. Their effect is precisely the same as though the capacity of the aerial section were reduced by a quantity, M, which is of the same dimension or character as K. Hence, our retardance equation becomes

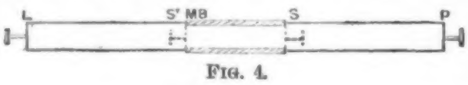


FIG. 4.

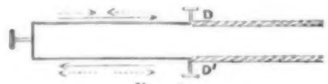


FIG. 5.

$$R\,(K - M) = t$$

Thus it happens that the London-Paris telephone works better than was expected. The nature of M is probably equivalent to about 0·0075 φ per mile, and therefore K should be also about 0·0075 φ instead of 0·0156 φ per mile. This helpful action of mutual induction is present in all long circuits, and it is the reason why we were able to speak to Brussels and even to Marseilles. It also appears in every metallic loop, and vitiates the measurements of electromagnetic inertia and of capacity of loops. Thus, if we measure the capacity of a loop as compared with a single wire, the amount per mile may be 50 per cent. greater than it ought to be; while if we measure the capacity of one branch of a circuit under the conditions of the London-Paris telephone line, it may be 50 per cent. less than it ought to be. This effect of M is shown by the dotted line in Fig. 1.

Telephonic currents—that is, currents induced in the secondary wire of an induction coil due to the variation of microphonic currents in the primary wire—are not alternating currents. They do not follow the constant periodic law, and they are not true harmonic sine functions of the time. The microphonic currents are intermittent or pulsatory, and always flow in the same direction. The secondary currents are also always of the same sign, as are the currents in a Ruhmkorff coil, and as are the currents in high vacua with which Crookes has made us so familiar. Moreover, the frequency of these currents is a very variable quantity, not only due to the various tones of voices, but to the various styles of articulation. Hence the laws of periodic alternate currents following the sine function of the time fail when we come to consider microphones and telephones. It is important to bear this in mind, for nearly everything that has hitherto been written on the subject assumes that telegraphic currents follow the periodic sine law. The currents derived from Bell's original magneto-transmitters are alternate, and comply more nearly with the law. The difference between them and microphones is at once perceptible. Muffling and disturbance due to the presence of electromagnetic inertia become evident, which are absent with microphones. I tested this between London and St. Margaret's, and found the effect most marked.

7. *Lightning.*—A metallic telephone circuit may have a static charge induced upon it by a thunder cloud, as shown in Fig. 6. Such a charge is an electric strain which is released when the charged cloud flashes into the earth or into a neighboring cloud. If there be electromagnetic inertia present, the charge will surge backward and forward through the circuit until it dies out. If there be no E.M.F. present it will cease suddenly, and neutrality will be attained at once. Telephone circuits indicate the operation by peculiar and characteristic sounds. An iron wire circuit produces a long swish or sigh, but a copper wire circuit like the Paris-London telephone emits a short, sharp report, like the crack of a pistol, which is sometimes startling, and has created fear, but there is no danger or liability to shock. Indeed, the start has more than once thrown the listener off his stool, and has led to the belief that he was knocked down by lightning.

FIG. 6.

8. The future of telephone working, especially in large cities, is one of underground wires, and the way to get over the difficulties of this kind of work is perfectly clear. We must have metallic circuits, twisted wires, low resistance, and low capacity. In Paris a remarkable cable, made by Fortin-Herman, gives an exceedingly low capacity—viz., only 0·069 φ per mile. In the United States they are using a wire insulated with paper which gives 0·08 φ per mile. We are using in London Fowler-Waring cable giving a capacity of 1·8 φ per mile, the capacity of gutta-covered wire being 3 φ per mile.

THE MANUFACTURE OF PHOSPHORUS BY ELECTRICITY.

ONE of the most interesting of the modern applications of electricity to the manufacture of chemicals is to be found in the recently perfected process known as the Readman-Parker process, after the inventors Dr. J. B. Readman, F.R.S.E., etc., of Edinburgh, and Mr. Thomas Parker, the well known practical electrician, of Wolverhampton.

Before giving an account of this process, which has advanced beyond the experimental to the industrial stage, it may be well to recall the fact that for several years past Dr. Readman has been devoting an enormous expenditure of labor, time and money to the perfection of a process which shall cheapen the production of phosphorus by dispensing altogether with the use of sulphuric acid for decomposing the phosphate of lime which forms the raw material of the phosphorus manufacturer, and also with the employment of fire clay retorts for distilling the desiccated mixture of phosphoric acid and carbon which usually forms the second stage of the operation.

The success of the recent applications of electricity in the production of certain metals and alloys led Dr. Readman to try this source of energy in the manufacture of phosphorus, and the results of the first series of experiments were so encouraging that he took out provisional protection on October 18, 1888, for preparing this valuable substance by its means.

The experiments were carried on at this time on a very small scale, the power at disposal being very limited in amount. Yet the elements of success appeared to be so great, and the decomposition of the raw material was so complete, that the process was very soon prosecuted on the large scale.

After a good deal of negotiation with several firms that were in a position to supply the electric energy required, Dr. Readman finally made arrangements with the directors of the Cowles Company, limited, of Milton, near Stoke-on-Trent, the well known manufacturers of alloys of aluminum, for a lease of a portion of their works and for the use of the entire electrical energy they produced for certain portions of the day.

The experiments on the large scale had not advanced very far before Dr. Readman became aware that another application for letters patent for producing phosphorus had been made by Mr. Thomas Parker, of Wolverhampton, and his chemist, Mr. A. E. Robinson. Their joint patent is dated December 5, 1888, and was thus applied for only seven weeks after Dr. Readman's application had been lodged.

It appeared that Mr. Parker had conducted a number of experiments simultaneously but quite independently of those carried on by Dr. Readman, and that he was quite unaware—as the latter was unaware

—of any other worker in this field. It was no small surprise, therefore, to find during an interview which took place between these rival inventors some time after the date referred to, that the two patents were on practically the same lines, namely, the production of phosphorus by electricity.

Their interests lay so much together that, after some delay, they arranged to jointly work out the process, and the result has been the formation of a preliminary company and the erection on a large scale of experimental plant in the neighborhood of Wolverhampton to prove the commercial success of the new system of manufacturing phosphorus.

Before describing these experimental works it may be as well to see with what plant Dr. Readman has been working at the Cowles Company's works. And here we may remark that we are indebted to a paper read by Dr. Readman at the Philosophical Institution, Edinburgh, a short time ago; this paper being the third of a series which during the last year or two have been read by the same scientist on this branch of chemical industry. Here is an abstract giving a description of the plant. The works are near the Milton Station, on the North Staffordshire Railway. The boilers for generating the steam required are of the Babcock-Wilcox type, and are provided with "mechanical stokers;" the steam engine is of 600 horse power, and is a compound condensing horizontal tandem, made by Messrs. Pollitt & Wigzel, of Sowerby Bridge. The fly wheel of this engine is 20 feet in diameter, and weighs 30 tons, and is geared to the pulley of the dynamo, so that the latter makes five revolutions for each revolution of the engine by rope driving gear, consisting of eighteen ropes. The engine is an extremely fine specimen of a modern steam engine; it works so silently that a visitor standing with his back to the engine railings, at the time the engine is being started, cannot tell whether it is in motion or not.

With regard to the dynamo, the spindle is of steel, 18 feet long, with three bearings, one being placed on either side of the driving pulley. The diameter is 7 inches in the bearings and 10 inches in the part within the core. This part in the original forgings was 14 inches in diameter, and was planed longitudinally, so as to leave four projecting ribs or radial bars on which the core disks are driven, each disk having four key ways corresponding to these ribs. There are about 900 of these disks, the external diameter being 20 inches and the total length of the core 36 inches.

The armature winding consists of 128 copper bars, each ⅞ in. deep, measured radially, by ⅜ in. wide. These bars are coupled up so as to form thirty-two conductors only; this arrangement has been adopted to avoid the heating from the Foucault currents, which, with 1½ in. conductors, would have been very considerable. The bars are coupled at the ends of the core across a certain chord and are insulated.

The commutator is 20 inches long, and has sixty-four parts. The current is collected by eight brushes mounted on a separate ring, placed concentric to the commutator; and the current is led away from these brushes by a large number of thin bands of sheet copper strapped together into convenient groups. The field magnets are of the horizontal double type.

As this machine is virtually a series wound machine, the magnet coils each consist of a few turns only of forged copper bars, 1½ in. wide by 1 in. thick, forged to fit the magnet cores.

There is no insulation other than mica wedges to keep the bars from touching the core.

The dynamo furnishes a current of about 5,000 amperes, with an E. M. F. of 50 to 60 volts, and three years ago was claimed to be the largest machine, at least as regards quantity of current, in the world.

The current from the dynamos is led by copper bars to an enormous "cut out," calculated to fuse at 8,000 amperes. This is probably one of the largest ever designed, and consists of a framework carrying twelve lead plates, each 3½ in. × $\frac{1}{16}$th in. thick. A current indicator is inserted in the circuit consisting of a solenoid of nine turns. The range of this indicator is such that the center circle of 360°=8,000 amperes.

The electrodes consisted of a bundle of nine carbons, each 2½ in. in diameter, attached by casting into a head of cast iron. Each carbon weighs 20 lb., and, when new, is about 48 inches long.

The head of the electrode is screwed to the copper rods or "leads," which can be readily connected with the flexible cable supplying the current.

The electric furnaces are rectangular troughs built of fire brick, their internal dimensions being 60 in. × 20 in. × 36 in. deep. Into each end is built a cast iron tube, through which the carbon electrodes enter the furnace.

The electrodes are so arranged that it is possible by means of screwing to advance or withdraw them from the furnace.

The whole current generated by the great dynamo of the Cowles Company was passed through the furnace.

In the experiments raw materials only were used, for it was evident that it was only by the direct production of phosphorus from the native minerals which contain it, such as the phosphates of lime, magnesia, or alumina that there was any hope of superseding, in point of economy, the existing process of manufacture.

In the furnaces as used at Milton much difficulty was experienced in distributing the heat over a sufficiently wide area. So locally intense indeed was the heat within a certain zone, that all the oxygen contained in the mixture was expelled and alloys of iron, aluminum, and calcium combined with more or less silicon, and phosphorus were produced. Some of these were of an extremely interesting nature.

We now turn to a short account of the works and plant which have been erected near Wolverhampton to prove the commercial success of the new system of manufacturing phosphorus.

The ground is situated on the banks of a canal and extends to about 10 acres, which are wholly without buildings except those which have been erected for the purposes of these industrial experiments. These consist of boiler and engine houses, and large furnace sheds.

There are three Babcock & Wilcox steam boilers of 160 horse power each, and each capable of evaporating 5,000 lb. of water per hour. The water tubes are 18 ft. long × 4 inches diameter, and the steam and water drums 42 in. in diameter and 23½ ft. long, of steel $\frac{7}{16}$ths. in. thick, provided with a double dead head safety valve, stop valves, blow-off cock, water gauges, and steam gauge.

The total heating surface on each boiler is 1,619 square feet and the total grate surface is 30 square feet.

The boilers are worked at 160 lb. pressure.

The engine is a triple compound one of the type supplied for torpedo boats, and built by the Yarrow Shipbuilding Company. It is fitted with a Pickering governor for constant speed. The engine is capable of delivering (with condenser) 1,200 indicated horse power, and without condenser 250 indicated horse power less.

With steam at 170 lb. pressure the engine worked at 350 revolutions per minute, but it has been rearranged so as to deliver 700 indicated horse power with 160 lb. steam pressure without condenser, and at 300 revolutions per minute:

The high pressure cylinder is 14½ inches diameter.
" intermediate " " 25 " "
" low pressure " " 32 " "
" stroke is 16 inches.

The dynamo for producing the requisite amount of electric current supplied to the furnaces is one of the well known Elwell-Parker type of alternating current dynamos, designed to give 400 units of electrical energy, equivalent to 536 indicated horse power.

The armature in the machine is stationary, with double insulation between the armature coils and the core, and also between the core and the frame, and is so arranged that its two halves may be readily connected in series or in parallel in accordance with the requirements of the furnaces, *e. g.*, at an electromotive force of 80 volts it will give 5,000 amperes, and at 160 volts, 2,500 amperes when running at 300 revolutions per minute.

The exciting current of the alternator is produced by an Elwell-Parker shunt wound machine, driven direct from a pulley on the alternator shaft, and so arranged as to give 90 amperes at 250 volts when running at a speed of 800 revolutions per minute. From 60 to 70 amperes are utilized in the alternator, the remainder being available for lighting purposes (which is done through accumulators) and general experimental purposes.

The process is carried out in the following way: The raw materials, all intimately and carefully mixed together, are introduced into the furnace and the current is then turned on. Shortly afterward, indications of phosphorus make their appearance.

The vapors and gases from the furnace pass away to large copper condensers—the first of which contains hot and the second cold water—and finally pass away into the air.

As the phosphorus forms, it distills off from the mixture, and the residue forms a liquid slag at the bottom of the furnace. Fresh phosphorus yielding material is then introduced at the top. In this way the operation is a continuous one, and may be continued for days without intermission.

The charges for the furnace are made up with raw material, *i. e.*, native phosphates without any previous chemical treatment, and the only manufactured material necessary—if such it may be called—is the carbon to effect the reduction of the ores.

The crude phosphorus obtained in the condensers is tolerably pure, and is readily refined in the usual way.

Dr. Readman and Mr. Parker have found that it is more advantageous to use a series of furnaces instead of sending the entire current through one furnace. These furnaces will each yield about 1½ cwt. of phosphorus per day.

Analyses of the slag show that the decomposition of the raw phosphates is very perfect, for the percentage of phosphorus left in the slag seldom exceeds 1 per cent.—*Chemical Trade Journal.*

NEW BLEACHING APPARATUS.

THE apparatus forming the subject of this invention was designed by Francis A. Cloudman, Erwin B. Newcomb, and Frank H. Cloudman, of Cumberland Mills, Me., and comprises a series of tanks or chests, two or more in number, through which the material to be bleached is caused to pass, being transferred from one to the next of the series in order, while the bleaching agent is caused to pass through the series of chests in the reverse order, and thus acts first and at full strength upon the materials which have previously passed through all but the last one of the series of chests and have already been subjected to the bleaching agent of less strength.

For convenience, the chest in which the material is first introduced will be called the "first of the series" and the rest numbered in the order in which the material is passed from one to the other, and it will be understood that any desired number may be used, two, however, being sufficient to carry on the process.

The invention is shown embodied in an apparatus properly constructed for treating pulp used for the manufacture of paper, and for convenience the material to be bleached will be hereinafter referred to as the pulp, although it is obvious that similar apparatus might be used for bleaching other materials, although the apparatus might have to be modified to adapt it for conveying other materials of different nature than pulp from one bleaching chest to the other and for separating out the bleaching liquid and conveying it from one chest to the other in the reverse order to that in which the material passes from one chest to the next.

The pulp material with which the apparatus herein illustrated is intended to be used is retained in suspension in the bleaching liquid and flows readily through ducts or passages provided for it in the apparatus in which the pulp to be bleached and the bleaching liquid are introduced together at the bottom of each chest and flow upward therethrough, while at the top of each chest there are two conveyors, one for carrying the pulp from one chest to the next in order, while the other carries the bleaching liquid from one tank to the next in the reverse order, the said conveyors also acting to partially separate the pulp from the liquid in which it has been suspended during its upward passage through the chest.

Suitable agitators may be employed for thoroughly mixing the materials in the chest and in the apparatus shown the bleaching agent and material to be bleached pass through each chest in the same direction—namely from the bottom to the top—although they are carried from one chest to the next in the reverse order, the material to be bleached being primarily introduced into the chest at one end of the series, while the bleaching agent or solution is introduced primarily into the chest at the other end of the series.

Fig. 1 is a plan view of an apparatus for bleaching in accordance with this invention, comprising a series of four chests, and Fig. 2 is a vertical longitudinal section of a modified arrangement of two chests in line with one another, and with the conveyor for the material to be bleached and the passage through which said material passes from the top of one chest into the bottom of the next chest in the plane of section.

The chests, $a\,a^2\,a^3\,a^4$, may be of any desired shape and dimensions and any desired number may be used. Each of said chests is provided with an inlet passage, *b*, opening into the same near its bottom, and through this passage the materials are introduced. The unbleached material, which may be paper pulp or material which is readily held in suspension in a liquid and is capable of flowing or being conveyed from one point to another in a semi-fluid condition, is introduced through the inlet passage, *b*, to the first chest, *a*, of the series, said pulp preferably having had as much as possible of the liquid in which it was previously suspended removed without, however, drying it, and, together with the said pulp, the bleaching agent which has previously passed through the other chests of the series, as will be hereinafter described, is introduced so that both enter together at the lower portion of the first chest, *a*, of the series. The said materials are caused to flow into the chest continuously, so that the portion at each moment entering tends to displace that which has already entered, thus causing the materials to rise gradually or flow upward from the bottom to the top of the chest.

Suitable stirring devices or agitators, *c*, may be employed to keep the pulp in suspension and to expose it thoroughly and uniformly to the liquid introduced with it.

Fig 1

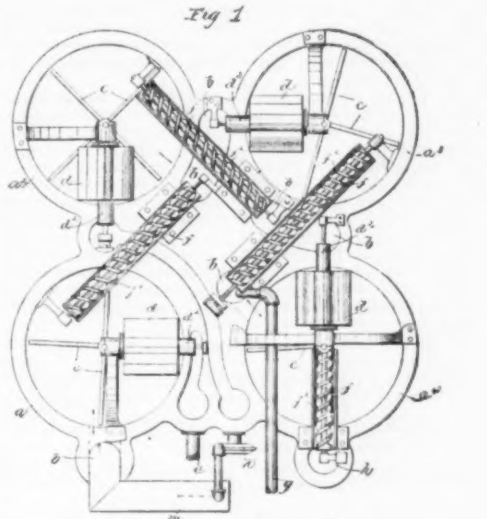
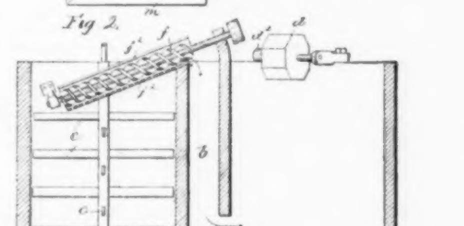


Fig 2.



When the materials (the pulp and the bleaching liquid) arrive at or near the top of the chest, they are partially separated from one another and removed from the chest at substantially the same rate that they are introduced, as follows: Each chest is provided at its upper part with a liquid conveyor, *d*, having a construction similar to that of the device known as a "washer" in paper making machinery, consisting of a rotating drum, the periphery of which is covered with gauze, which permits the liquid to pass into it, but excludes the pulp suspended in the liquid, the said drum containing blades or buckets that raise the liquid which thus enters through the gauze and discharges it at d^2 near the axis of said drum. There is one of these washers in each one of the series of chests, and each discharges the liquid taken from its corresponding chest into the inlet pipe of the next preceding chest of the series, the washer in the chest, a^4, for example, delivering into the inlet passage, *b*, of the chest, a^3, and so on, while the washer of the first chest, *a*, of the series delivers into a discharge pipe, *e*, through which the liquid may be permitted to run to waste or conveyed to any suitable receptacle, if it is desired to subject it to chemical action for the purpose of renewing its bleaching powers or obtaining the chemical agents that may be contained within it.

The operation of the washers in removing the liquid from the upper part of the chest tends to thicken the pulp therein, and the said thickened pulp is conveyed from one chest to the next in the series by any suitable conveying device, *f* (shown in this instance as a worm working in a trough or case, f^2), which may be made foraminous for the purpose of permitting the liquid to drain out of the pulp that is being carried through by the worm, in order that the pulp may be introduced into the next chest of the series as free as possible from the liquid in which it has been suspended while in the chest from which it is just taken. The pulp is thus conveyed from one chest in the series to the inlet passage leading to the next chest of the series, and in the

said inlet passage it meets the liquid coming in the reverse order from the next chest beyond in the series, the pulp and liquid thus commingling in the inlet pipe and entering the chest together, and being thoroughly mixed by the agitators in passing through the chest by the continued action of fresh material entering and of the conveyors taking the material out from the chests. In the last of the series of chests into which the pulp is introduced the fresh or strong bleaching liquid is introduced through a suitable inlet pipe, *g*, and the pulp conveyor, *f*, that takes the pulp from the last chest, delivers it into a pipe, *h*, by which it may be conveyed to any desired point, the said pulp having been sufficiently bleached before arriving at the said pipe, *h*. It will be seen that by these means all the pulp is thoroughly and uniformly subjected to the bleaching agent and that the bleaching is gradually performed in all parts of the pulp, which is first acted upon by the weaker bleaching agent that has previously operated upon the pulp before treated, and that finally, when nearly bleached, the pulp is acted upon by the bleaching material of full strength, this action being far more efficient than when the materials are simply mixed together, the unbleached material with the strong bleaching agent, and allowed to remain together until the bleaching operation is finished, in which plan the bleaching agent loses its strength as the bleaching operation approaches completion, so that when the pulp is nearly bleached it is operated upon by a very weak bleaching agent. By having the pulp transferred from one chest to the next in the reverse order to that in which the liquid is transferred it will be seen that all parts of the pulp are acted upon uniformly and equally and that the operation may go on continuously for an indefinte period of time without necessitating stopping to empty the vats, as is the case when the liquor only is transferred from one vat to the next. A pump may be used for lifting the bleaching liquid, as shown, for example, at *k*, Fig. 1, where said pump is used to raise the liquid delivered from the chest, a^3, and discharge it into the trough, *m*, by which the pulp is carried to the inlet pipe, *b*. By the use of the pump, *h*, a stronger flow of the liquid into the pipe *b*, of the first chest, *a*, is effected than if it were taken directly from the washer of the chest, a^3, which is desirable, as the pulp is delivered in the trough, *m*, with but little moisture.

It is obvious that the construction of the apparatus may be varied considerably without materially changing the essential features of operation. For example, the washers might be dispensed with and the liquid permitted to flow through suitable strainers from one chest to the next in order, by gravity, the successive chests in the order of the passage of the pulp being placed each at a higher level than the preceding one, and it is also obvious that the construction of the pulp conveyors might be widely varied, it being essential only that means should be provided for removing the pulp from one chest and delivering it into the next while carrying only a small amount of the liquid from one chest to the next with the pulp.

THE USE OF COMPRESSED AIR IN CONJUNCTION WITH MEDICINAL SOLUTIONS IN THE TREATMENT OF NERVOUS AND MENTAL AFFECTIONS.

Being a New System of Cerebro-spinal Therapeutics.

By J. Leonard Corning, A.M., M.D., New York, Consultant in Nervous Diseases to St. Francis Hospital, St. Mary's Hospital, the Hackensack Hospital, etc.

To merely facilitate the introduction of medicinal agents into the system by way of the air passages, in the form of gases, medicated or non-medicated, has heretofore constituted the principal motive among physicians for invoking the aid of compressed air. The experiments of Paul Bert with nitrous oxide and oxygen gas, performed over fourteen years ago, and the more recent proposals of See, are illustrations in point.

The objects of which I have been in search are quite different from the foregoing, and have reference not to the introduction of the remedy, but to the enhancement of its effects after exhibition. Let me be more explicit on this point, by stating at once that, in contradistinction to my predecessors, I shall endeavor to show that by far the most useful service derivable from compressed air is found in its ability to enhance and perpetuate the effects of soluble remedies (introduced hypodermically, by the mouth, or otherwise) upon the internal organs, and more especially upon the cerebro-spinal axis. Some chemical affinity between the remedy employed and the protoplasm of the nerve cell is, of course, assumed to exist; and it is with the enhancement of this affinity—this bond of union between the medicinal solution and the nervous element—that we shall chiefly concern ourselves in the following discussion.

By way of introduction, I may recall the fact that my attention was directed several years since to the advisability of devising some means by the aid of which medicinal substances, and more especially anæsthetics, might be made to localize, intensify, and perpetuate their action upon the peripheral nerves. The simple problem in physiology and mechanics involved in this question I was fortunate enough to solve quite a long time ago; and I must confess that in the retrospect these undertakings in themselves do not seem to me of great magnitude, though in their practical application their significance appears more considerable. Herein lies, it may be, the explanation of the interest which these studies excited in the profession at the time of their publication. These things are, however, a part of medical history; and I merely refer to them at this time because they have led me to resume the solution of a far greater problem—that of intensifying, perpetuating, and (to some extent at least) localizing the effects of remedies upon the brain and spinal cord. I speak of resuming these studies because, as far back as 1880 and 1882, I made some attempts—albeit rather abortive—in the same direction.

In constructing the argument for the following study, I am beholden more especially to three facts, the knowledge of which came to me as the direct result of experimental tests. One may place confidence, therefore, in the procedure which I have based upon these premises, for at no point, I think, in the following argument will mere affirmation be found to have usurped the place of sound induction. Without anticipating further, then, let me specify as briefly as may be the nature of these facts.

Premises of Argument. *First Fact.*—The amount of ether, chloroform, chloral hydrate, the bromides, strychnine, and many other remedies, required to produce physiological effects upon the cerebro-spinal mechanism may be reduced by first securing a ligature around the central portion of one or several of the limbs of an animal, so as to interrupt both the arterial and venous circulation.

The proof and explanation of this may be thus presented:

In the first place, it is well known that children and small animals are affected by much smaller quantities of anæsthetics and other medicinal substances than are required to produce equal effects in men and large animals.

At first sight, there appears to exist a certain definite relation between the weight of the animal and the quantity of medicament required to produce physiological effects. On closer inquiry, however, we find behind this proposition the deeper truth that the real proportion is between the magnitude of the blood-mass and the amount of medicament. Thus, if we withdraw a considerable amount of blood from a large dog, we may be able to affect him by much smaller doses than those required under ordinary circumstances; and, among human beings, we find the anæmic much more susceptible to remedies than the full-blooded of equal weight.

The degree of saturation of the blood-mass with the remedy is obviously, then, the principal thing; the greater the amount of blood, the more remedy—everything else being equal—we shall have to give in order to obtain definite results.

If we wish to embody the proposition in a mathematical statement, we may do so in the following simple manner:

Let *a* represent the total quantity of blood, *b* the amount of remedy exhibited, and *x* the magnitude of the physiological effect. We shall then have the simple formula, $x = \frac{b}{a}$

Again, if we withdraw a certain quantity of blood from the circulation by venesection, and call that amount *d*, we shall then have the formula $x = \frac{b}{a - d}$

But, if we wish to act upon the organs of the trunk, and more especially upon those contained within the cerebro-spinal canal, it is not necessary to resort to such a drastic expedient as copious blood-letting; for, in place of this, we may dam up and effectually eliminate from the rest of the body a certain amount of blood by passing a ligature around the central portion of one or several extremities, so as to interrupt the circulation in both artery and vein. When this has been done it is clear that we may introduce a remedy into the system by way of the stomach, or hypodermically into some portion of the trunk; and it is equally certain that a remedy so introduced will be diluted only in the ratio of the amount of blood freely circulating, and more especially by that contained within the trunk and head. That which is incarcerated behind the ligatures is as effectually withdrawn from the realm of physiological action as though it had been abstracted by the surgeon's knife. Elimination by the knife and elimination by the ligature are, for present purposes, then, one and the same thing. Hence, if we let *d'* represent the amount of blood incarcerated behind the ligatures, *x* the magnitude of the physiological effect which we are seeking, *b* the amount of remedy exhibited, and *a* the total amount of blood contained in the whole organism, we shall have the formula, $x = \frac{b}{a - d'} = \frac{b}{a - d}$

Several years since, I had an excellent opportunity of proving the truth of the foregoing, in connection with the administration of ether in the case of a patient who resisted all attempts to anæsthetize him in the ordinary way.

The case in question was a man under treatment at the Manhattan Eye and Ear Hospital, upon whom it was deemed advisable to perform an operation. As has been said, the ordinary means of inducing anæsthesia had proved ineffectual, for the man was a confirmed drunkard; and it was at this juncture that I was called in consultation and requested by my friend, Dr. David Webster, one of the surgeons of the hospital, to endeavor to devise some means of getting the man under the influence of the anæsthetic.

The procedure which I suggested was this:* Around the upper part of each thigh a flat rubber tourniquet was tightly drawn and secured in place in the usual manner. By this means the sequestration of all the blood contained in the lower limbs was accomplished; but, inasmuch as both artery and vein were compressed, only the amount of blood usually contained in each limb was shut off from the rest of the body—which would not have been the case had we contented ourselves with merely compressing the veins, as some have done.

In subsequently commenting on my published report of this case, that most accomplished writer and physician, Henry M. Lyman—than whom there is no greater authority on anæsthesia—observes that the plan proposed and adopted by me on this occasion (that of compressing both vein and artery) is far preferable to compression of the vein alone.

The reason for this is not far to seek. When we compress the veins alone there is a rapid accumulation of blood in the extremities through the accessions derived from the uninterrupted arteries. Now, as this blood is derived from the trunk, and consequently also from the organs contained within the cerebro-spinal canal, there is danger of syncope and even heart failure. When, on the other hand, both artery and vein are compressed no such derivative action occurs, and all danger is, consequently, removed. With an apology for this brief digression, I now return to the interesting case which has given rise to it.

Having, as previously stated, applied tourniquets to the central portion of the lower limbs, the ether cap was placed over the mouth and nose of the patient, and in an incredibly short time he was unconscious, and the surgeons were able to go on with the operation.

The late Dr. Cornelius R. Agnew and many other members of the staff of the hospital were present, and gave emphatic expressions of approval.

Dr. F. W. Ring, assistant surgeon to the Manhattan Eye and Ear Hospital, declared that both the amount of ether and the time consumed in its administration were infinitesimal when compared with what had been expended in previous efforts at inducing anæsthesia in the usual way. The facts brought out on this occasion with regard to the administration of ether have since been repeatedly verified by different observers; so that at the present day their validity cannot be questioned. I will merely add, however, that I have long known that the dosage of phenacetin, antipyrine, morphine, chloralamid, chloral, the bromides, and many other remedies might be reduced by resort to the same procedure; all of which is merely equivalent to stating that their pharmaco-dynamic energy may be increased in this way. And this brings us to the second fact, which requires no special elaboration, and may be stated thus:

Second Fact.—The duration of the effect of a remedy upon the cerebro-spinal axis is in the inverse ratio of its volatility; and this is equally true whether the remedy be given with or without the precautions previously detailed. For example, the anæsthetic effects of ether disappear shortly after removal of the inhaler, whether we apply tourniquets to the extremities or not; but, on the other hand, the analgesic influence of antipyrin, phenacetin, morphine, and other like remedies lasts very much longer, and their dose may be reduced, or—what is the same thing—their pharmaco-dynamic potency may be enhanced by the sequestration of the blood contained within the extremities. So far as I know, I was the first to announce this fact. In so far as a simple expression of the above truth is concerned, we may employ the following formula:

Let *a* represent the normal blood-mass contained in the entire body, *d'* the amount of blood sequestrated by the ligatures, *b* the amount of the remedy, *c* the volatility of the remedy, and *x* the pharmaco-dynamic potency of which we are in search; we shall then have

$$x = \frac{b}{(a - d') \times c}$$

We now arrive at our third fact, which will require more extensive elaboration.

Third Fact.—The pharmaco-dynamic potency of stimulants, sedatives, analgesics, and probably of all remedies which possess a chemical affinity for nervous matter, is enhanced by exhibiting them (the remedies) in solution or soluble form—hypodermically, by the mouth, or per rectum—while the subject remains in a condensed atmosphere. And, as a corollary, it may be stated that this increase, this enhancement of the potency of the remedy is, within certain limits, in the ratio of the atmospheric condensation.

To express this truth mathematically is not difficult. Thus, when *a* represents the amount of blood of the whole body, *b* the amount of the remedy, *e* the amount of atmospheric compression, and *x* the pharmaco-dynamic potentiality which we are seeking, we shall then have the simple formula:

$$x = \frac{b \times e}{a}$$

A definite conception of the truth of this proposition will, I think, be more readily attained by the presentation of the steps which led me to its discovery.

Let me begin, then, by stating that my attention was attracted several years ago by that unique complex of symptoms known as the "caisson or tunnel disease." As most physicians are aware, the caisson disease is an affection of the spinal cord, due to a sudden transition from a relatively high atmospheric pressure to one much lower. Hence, those who work in caissons, or submerged tunnels, under an external pressure of two atmospheres or even more, are liable to be attacked by the disease shortly after leaving the tunnel. The seizure never, however, occurs while the subject is in the caisson, or in other words, while he remains under pressure. Moreover, when the transition from the condensed atmosphere to that of ordinary density is gradually accomplished, which may be done by letting the air escape from the lock very slowly, the caisson disease is rarely if ever set up. It is the systematic disregard of this principle by those who work in compressed air that is responsible, or largely responsible, for the occurrence of the disease.

The chief clinical features of the caisson disease are pain, which may be relatively mild, as when confined to a circumscribed area of one extremity, or of frightful intensity, as when it appears in the ears, knees, back, or abdomen; anæsthesia and paralysis, usually of paraplegic type; bladder symptoms, assuming the form of retention or incontinence; and, more rarely, rectal disturbances (usually incontinence).

These phenomena, or rather some of them, appear some time within half an hour after the subject has left the compressed atmosphere. It was while investigating this most interesting affection as it occurred in the course of the construction of the Hudson River tunnel, that I was able, at the same time, to study the effects of compressed air upon the organism, and especially upon the nervous system, as exhibited in a large number of persons.

The results of these studies I now submit without hesitation, and in all candor, to the judgment of the profession, believing, as I certainly do, that their practical significance from a neuro-therapeutic standpoint is assured. Without anticipating, however, let me state that the first thing which impressed me about compressed air was its extraordinary effect upon cerebral and cerebro-spinal function.

Those who remain for a certain length of time, not too long, however, in the condensed atmosphere, exhibit a most striking exacerbation of mental and physical vigor. They go up and down ladders, lift heavy weights, are more or less exhilarated, and, in short, behave as though under the influence of a stimulant.

Hardly had I observed these things, which are perfectly well known to those who have been able to

* On the "Effective and Rapid Induction of General Anæsthesia," the New York *Medical Journal*, October 22 and December 24, 1887.

familiarize themselves with the ordinary effects of compressed air as used in caissons and submarine works of various kinds, when my attention became attracted by what at first appeared to be a phenomenon of trivial importance. In a word, I observed that some of the men exposed to the effects of the compressed air were more exhilarated by it than others. Upon superficial reflection one might have supposed that this discrepancy in physiological effect was to be accounted for merely on the basis of constitutional idiosyncrasy; maturer thought, however, convinced me that the exaggerated effects of the condensed air were both too numerous and too constant to be amenable to such an explanation. This led me to study the habits of the men; and thus it was that I arrived at a discovery of real practical value to neurotherapy. To be brief, I found that a certain percentage of the men, before entering the compressed air employed in the construction of the Hudson River tunnel, were in the habit of drinking a quantity of alcohol, usually in the form of whisky. So long as these men remained outside the tunnel, where the atmospheric conditions were normal, they were not visibly affected by their potations. When, however, they entered the compressed air of the tunnel, but a short time elapsed before they became exhilarated to an inordinate degree, acting, as one of the foremen graphically expressed it, "as though they owned the town."

On the other hand, when the customary draught of alcohol was withheld from them, these same men were no more, if as much, exhilarated on entering the compressed air as were their fellows.

The effects of alcohol, then, are enhanced by exposing the subject to the influence of an atmosphere condensed to a considerable degree beyond that of the normal atmosphere.

Acting on the hint derived from this discovery, I proceeded to administer absinthe, e ther, the wine of coca, vermouth, champagne, and other stimulants, before exposing the subject to the influence of the condensed atmosphere, and invariably observed analogous effects, *i. e.*, palpable augmentation of the physiological effects of the remedy.

Upon what principle does this augmentation of physiological effect depend? how is it to be accounted for?

In my opinion, the answer to this question may be given as follows: In the first place, we know that the primary effect of the compressed air upon the organism must be to force the blood from the surface of the body toward the interior, and especially into the cerebro-spinal canal. Or, to express it more succinctly, the blood will be forced in the direction of the least resistance, that is, into the soft organs inclosed by bony walls, which latter completely shut out the element of counter-pressure. Now, when the blood stream is freighted with a soluble chemical of some sort—let us say, for the present, with alcohol—this medicated blood will exert its greatest chemical effect where the tension—the pressure—is greatest, that is, in the cerebro-spinal canal. The reason for this is found in the fact that endosmosis is most pronounced where the blood pressure is greatest. This explanation of why the effects of alcohol are enhanced by exposing the individual who has taken it to the effects of a condensed atmosphere will, I believe, appeal to the physiological conceptions of most medical men. It was the above course of reasoning which, at this stage of the argument, led me to the idea that, just as the effects of stimulating substances are enhanced by exposing the subject to the influence of compressed air, so, inversely, sedatives and analgesics, when brought in solution into the blood stream either hypodermically or by the stomach, might be greatly enhanced in effect by causing the subject to remain, while under their influence, in a condensed atmosphere.

When I came to investigate the validity of these predictions, as I did shortly after the introduction of antipyrin, phenacetin, and the other members of the same group of compounds, I found my predictions verified, and, indeed, exceeded. To summarize the whole matter, I ascertained that not only could therapeutic effects be obtained from much smaller doses by exposing the subject to the influence of a condensed atmosphere, but, what was of equal interest, I found that the analgesic influence of the remedies was much more permanent, was prolonged, in short, by this mode of administration. When we consider how great must be the nutritive changes in the nervous system, and especially in the cerebro-spinal axis, consequent upon increasing the blood pressure in this way, I hardly think that these things should be matters of astonishment.

CONCERNING THE PRACTICAL APPLICATION OF THE FOREGOING FACTS.—Truths like the foregoing possess, however, much more than a theoretical interest, and we should be greatly lacking in perspicuity did we not seek to derive from them something further than a foundation for mere speculation. Indeed, the whole tenor of these facts is opposed to such a course, for, view them as we may, the thought inevitably arises that here are things which contain the germ of some practical acquisition. This, at least, is the impression which they engendered in my own mind—an impression which, being unable to rid my self of, I have allowed to fructify. Nor has regret followed this tenacity of purpose, since, by the *combination* of the three principles previously enunciated, I have been able to devise a procedure which, in my hands, has yielded flattering results in the treatment of a wide range of nervous affections, and notably so in melancholia, chorea, insomnia, neurasthenia, and painful conditions of various kinds.

RECAPITULATION OF ARGUMENT.—The method in question consists, then, in the combination of the three facts already elucidated. To recapitulate, they are:

1. That the effects of remedies upon the cerebro-spinal axis may be enhanced by the sequestration of the blood contained in one or more extremities, previous to the administration of the medicament. This is only another way of saying that the quantity of a remedy required to produce a given physiological effect may be reduced by any expedient which suspends, or sequestrates, the blood in one or more extremities. As has been previously said, however, care should be exercised to avoid dangerous exsanguination of the trunk, and consequently of the respiratory and cardiac centers contained in the medulla. This may be done by compressing the central portion of both artery and vein; but I shall presently indicate a better way of accomplishing the same thing.

2. The duration of the effect of a remedy upon the cerebro-spinal axis is in the inverse ratio of its volatility. For this reason the anæsthetic effects of ether disappear shortly after removal of the inhaler, whereas solutions of antipyrin, phenacetin, morphine, and other salts possessing an affinity for nervous tissue exert much more permanent effects upon the cerebro-spinal system.

It is evident, therefore, that the administration of remedies designed to exert an influence upon the central nervous system in the form of gases must be far inferior to the exhibition of potent solutions hypodermically or by the mouth.

3. The pharmaco-dynamic potency of stimulants, sedatives, analgesics, and probably of all remedies possessing a chemical affinity for nervous matter, is enhanced by exhibiting them (the remedies) in solution, or at least in *soluble form while the subject remains in a condensed atmosphere.*

And, as a corollary to this, it may be stated that this increase—this enhancement of theraputic effect—is, within physiological limits, in the ratio of the atmospheric condensation. By physiological limits we mean simply that there is a degree of atmospheric condensation beyond which we cannot go without jeopardizing the well-being of the subject.

(*To be continued.*)

EYESIGHT: ITS CARE DURING INFANCY AND YOUTH.*

By L. WEBSTER FOX, M.D.

MEDICAL science, as taught in our medical colleges to-day, has two objects in view: (1) the prevention of disease; (2) the amelioration of disease and its cure. Some of our advanced thinkers are suggesting a new mode of practice, that is the prevention of disease by proper hygienic measures. Chairs are being established and professors appointed to deliver lectures on hygiene. Of what value is the application of therapeutics if the human economy is so lowered in its vital forces that dissolution is inevitable? Is it not better to prevent disease than to try the cure after it has become established, or has honeycombed the constitution?

These few preliminary remarks are *apropos* to what is to follow in the subject which I have selected as the topic for discussion this evening.

Vision is the most useful of all the senses. It is the one gift which we should cherish and guard the most. And at no time in one's life is it more precious than in infancy and youth.

In infancy, when the child is developing, the one great avenue to the unfolding, or more properly speaking, the development, of the intellect is through the eye. The eye at this period holds in abeyance all the other senses. The child, when insensible to touch, taste, smell or hearing, will become aroused to action by a bright light or bright colors, or the movement of any illuminated object, proving to all that light is essential to the development of the first and most important sense. Again, the infant of but six days of age will recognize a candle flame, while its second sense and second in importance to its development—hearing—will not be recognized for *six* weeks to two months. Taste, touch and smell follow in regular sequence. Inasmuch as light makes thus early an impression on the delicate organ of vision, how necessary it behooves us to guard the infant from too bright lights or too much exposure in our bright climate. Mothers—not only the young mother with her first child, but also those who have had several children—are too apt to try to quiet a restless child by placing it near a bright flame; much evil to the future use of those eyes is the outgrowth of such a pernicious habit. Light throws into action certain cells of that wonderful structure of the eye, the retina, and an over stimulus perverts the action of those cells. The result is that by this over-stimulation the seeds of future trouble are sown. Let the adult gaze upon the arc of an electric light or into the sun, and for many moments, nay hours, that individual has dancing before his vision scintillations and phosphenes. His direct vision becomes blurred, and as in the case of a certain individual I have in mind, there may be a permanent loss of sight. Parents should take the first precaution in the child's life, and not expose it to a light too bright or glaring. When in the open air let the child's eyes be protected from the direct rays of the sun. While it is impossible to give all children the advantage of green fields and outdoor ramblings, yet nature never intended that civilization should debar the innocent child from such surroundings.

An anecdote is related of a French ophthalmic surgeon, that a distinguished patient applied to him for relief from a visual defect; the surgeon advised him to go into the country and look out upon the green fields. The green color with its soothing effect soon brought about a restoration of vision. What I wish to illustrate by this anecdote is that children should be allowed the green fields as their best friend in early life. It tones up the system and rests the eye. After outdoor exercise and plenty of it, we should turn our attention to the home surroundings of our little ones. The overheated rooms of the average American home I am sure have more to do with the growing tendency of weak eyes than we feel like admitting. Look at these frail hot-house plants, and can any one believe that such bodies nourished in almost pestilential atmosphere can nourish such delicate organs of vision, and keep them ready for the enormous amount of work each little eye performs daily? The brain developing so rapidly wills with an increasing rapidity the eye to do increasing duties; note the result—a tendency to impoverished circulation first, and the eye with its power to give the brain a new picture in an infinitesimal short space of time means lightning-like circulation—the eye must give way by its own exhaustion.

Civilization is the progenitor of many eye diseases.

After a boy has grown to that age when it becomes necessary for him to begin the education prescribed by the wise men, obstacles are placed in his way to aid again in causing deterioration of vision. It is not so much the overcrowded condition of our school rooms as the enormous amount of work that causes deterioration of sight. Our children begin their school life at a time when they are too young. A child at six years of age who is forced to study all day or even a part of a day will not run the same race that one will who commences his studies at ten—all things being equal. The law prescribes that so much time must be devoted to study, so many forms must be passed, so many books must be read, so many pages of composition written—all probably in badly lighted rooms, or by artificial light. Note the effect. First, possibly, distant vision gives way; the teacher, sympathizing with the overburdened child, tries to make the burden lighter by changing his position in the room or placing him under the cross light from a window; as the evil progresses, the child is taken to an ophthalmic surgeon, and the inevitable result, glasses, rightly called "crutches for the eyes," are given. What would be thought of a cause which would weaken the legs of that boy so that he would have to use crutches to carry him through life? If civilization be responsible for an evil, let our efforts be put forth in finding a remedy for that evil.

A discussion, in a recent number of the *British Medical Journal*,* on "The Claims and Limitations of Physical Education in Schools," has many valuable hints which should be followed by educators in this country. Dr. Carter, in the leading paper on this subject, makes the pregnant remark: "If the hope is entertained of building up a science of education, the medical profession must combine with the profession of teaching, in order to direct investigation and to collect material essential to generalization. Without such co-operation educational workers must continue to flounder in the morasses of empiricism, and be content to purchase relative safety at the cost of slow progress, or no progress at all." In other words, an advisory medical board should coexist with our board of public education, to try to hold in check or prevent a further "cruelty in trying to be kind." Private institutions of education recognize the importance of physical training and development, and in such institutions the deterioration of vision is in proportion less than in institutions where physical training is not considered. In one school of over 200 middle class girls, Dr. Carter found that, during a period of six years, no fewer than ten per cent. of the total number of girls admitted during that time have been compelled to take one or more terms' leave of absence, and of the present number twenty-eight per cent. have medical certificates exempting them from gymnastic exercise and 10·25 per cent. of the total present number wear eye glasses of some kind or other. From my own experience the same number of students in our schools would show about the same percentage of visual defects. These questions are of such growing importance that not only instructors, but the medical fraternity, should not rest until these evils are eradicated.

Dr. J. W. Ballantyne, of Edinburgh, in a lecture† on diseases of infancy and childhood, says: "The education of the young people of a nation is to that nation a subject of vital importance." The same writer quotes the startling statement made by Prof. Pfluger, that of 45,000 children examined in Germany more than one-half were suffering from defective eyesight, while in some schools the proportion of the short sighted was seventy or eighty per cent., and, crowning all, was the Heidelberg Gymnasium, with 100 per cent. These figures, the result of a careful examination, are simply startling, and almost make one feel that it were better to return to the old Greek method of teaching by word of mouth.

Prof. Pfluger attributes this large amount of bad sight to insufficient lighting of school rooms, badly printed books, etc. One must agree with a certain writer, who says: "Schools are absolute manufactories of the short sighted, a variety of the human race which has been created within historic time, and which has enormously increased in number during the present century." Granting that many predisposing causes of defective vision cannot be eliminated from the rules laid down by our city fathers in acquiring an education, it would be well if the architects of school buildings would bear in mind that light when admitted into class rooms should not fall directly into the faces of children, but desks should be so arranged that the light must be sufficiently strong and fall upon the desk from the left hand side. My attention has repeatedly been called to the cross lights in a school room. The light falling directly into the eyes contracts the pupil which is already contracted by the action of the muscle of accommodation in its effort to give a clearer picture to the brain. This has a tendency to elongate the eyeball, and as a permanent result we have near sightedness. Where the eyeball has an unnatural shortness this same action manifests itself by headaches, chorea, nausea, dyspepsia, and ultimately a prematurely breaking down of health. The first symptom of failing sight is a hyper-secretion of tears, burning of the eyelids, loss of eyelashes, and congestion either of the eyelids or the eyeball proper.

The natural condition of aboriginal man is far sighted. His wild life, his nomadic nature, his seeking for game, his watching for enemies, his abstention from continued near work, have given him this protection. Humboldt speaks of the wonderful distant vision of the South American Indians; another traveler in Russia of the power of vision one of his guides possessed, who could see the rings of Saturn. My recent examinations among Indian children of both sexes also confirm this. While the comparison is not quite admissible, yet the recent investigations carried on by Lang and Barrett, who examined the eyes of certain mammalia, found that the larger number were hypermetropic or far sighted. With all the difficulties which naturally surround such an examination they found that in fifty-two eyes of rabbits, thirty-six were hypermetropic and astigmatic, eight were hypermetropic only, five were myopic and astigmatic, and others presented mixed astigmatism. In the eyes of the guinea pig about the same proportion of hypermetropia existed. The eyes of five rats examined gave the following result: Some were far sighted, others were hypermetropic and astigmatic, one was slightly myopic and one had mixed astigmatism. Of six cows,

* A lecture delivered before the Franklin Institute, December 5, 1890.—*From the Journal of the Institute.*

* Nov. 1, 1890.

† *Lancet*, Nov. 1, 1890.

five were hypermetropic and astigmatic and one was slightly myopic.

Six horses were also examined, of which one had normal sight, three were hypermetropic and astigmatic, and two had a slight degree of astigmatism. They also examined other animals, and the same proportion of hypermetropia existed. These gentlemen found that as an optical instrument the eye of the horse, cow, cat and rabbit is superior to that of the rat, mouse and guinea pig.

I have for the last five years devoted considerable attention to the vision of the Indian children who are pupils at two institutions in this city. I have at various times made careful records of each individual pupil and have from time to time compared them. Up to the present there is a growing tendency toward myopia or short sightedness, *i. e.*, more pupils from year to year require near sighted glasses. The natural condition of their eyes is far sighted and the demands upon them are producing many nervous or reflex symptoms, pain over the frontal region and headaches. A good illustration of the latter trouble is showing itself in a young Indian boy, who is at present undergoing an examination of his vision as a probable cause for his headaches. This boy is studying music; one year ago he practiced two hours daily on the piano and studied from three to five hours besides. This year his work has been increased; he is now troubled with severe headaches, and after continued near work for some time letters become blurred and run together. This boy is far sighted and astigmatic; glasses will correct his defect, and it will be interesting to note whether his eyes will eventually grow into near sighted ones. I have several cases where the defective vision has been due entirely to other causes, such as inflammation of the cornea, weakening this part of the eye, and the effect in trying to see producing an elongation of the anterior portion of the eyeball, and this in turn producing myopia. The eye of the Indian does not differ materially from that of any deeply pigmented race. The eyeball is smaller than in the Caucasian, but when we examine the interior we find the same distribution of the blood vessels and same shape of the optic nerves. The pigment deposit in the choroid is excessive and gives, as a background to the retina, a beautiful silvery sheen when examined with the ophthalmoscope. One thing which I noticed particularly was the absence of this excessive deposit of pigment and absence of this watered silk appearance in the half breeds, they taking after the white race.

Many of the intraocular diseases common among the white children were also absent, especially those diseases which are the result of near work.

It is a well known fact among breeders of animals that where animals are too highly or finely bred, the eye is the organ first to show a retrogression from the normal. In an examination by myself some years ago among deaf mutes, I found the offspring of consanguineous marriages much affected, and while not only were many afflicted with inflammatory conditions of the choroid and retina, their average vision was much below the normal.

My quoting Messrs. Lang and Barrett's figures was to bring more prominently to the notice of my hearers the fact that the eyes of primitive man resembled the eyes of the lower mammalia and that the natural eye as an organ of vision was hypermetropic, or far sighted, and that civilization was the cause of the myopic or near sighted eye. Nature always compensates in some way. I grant that the present demands of civilization could not be filled by the far sighted eye, but the evil which is the outgrowth of present demands does not stop when we have reached the normal eye, but the cause once excited, the coats of this eye continue to give way, and myopia or a near sighted condition is the result.

Among three hundred Indians examined, I found when I got to the Creeks, a tribe which has been semi-civilized for many years, myopia to be the prevailing visual defect.

Without going into statistics, I am convinced from my experience that the State must look into this subject and give our public school system of education more attention, or we, as a people, will be known as a "spectacled race."

Myopia or short sightedness among the Germans is growing at a tremendous rate. While I do not believe that the German children perform more work than our own children, there is one cause for this defect which has never been touched upon by writers, and that is the shape of the head. The broad, flat face, or German type, as I would call it, has not the deep orbit of the more narrow, sharp-featured face of the American type. The eye of the German standing out more prominently, and, in consequence, less protected, is thereby more prone to grow into a near-sighted eye. One of the significant results of hard study was recently brought to my notice by looking over the statistics on the schools of Munich in 1889. In those schools 2,327 children suffered from defective sight, 996 boys and 1,331 girls.

Of 1,000 boys in the first or elementary class, 36 are short-sighted; in the second, 49; in the third, 70; in the fourth, 94; in the fifth, 108; in the sixth, 104; and in the last and seventh, 108. The number of short-sighted boys, therefore, from the first class to the seventh increases about three-fold. In the case of girls, the increase is from 37 to 119.

These statistics in themselves show us the effects of overwork, incessant reading or study by defective gas or lamp light, or from an over-stimulating light, as the arc light, late hours, dissipation, and frequent rubbing of the eye, also fatigue, sudden changes from darkness to light, and, what is probably worse than all, reading on railway trains. The constant oscillations of the car cause an over-activity of the muscle of accommodation, which soon becomes exhausted; the brain willing the eye to give it a clear photograph continues to force the ciliary muscle, which muscle governs the accommodation, in renewed activity, and the result may easily be foretold.

The fond parents finding that the vitiated air of the city is making their once rosy-cheeked children turn pale, seek a remedy in the fresh air of the country. The children find their way to city schools; this necessitates traveling so many miles a day in railway cars. The children take this opportunity of preparing their studies while *en route* to the city, and here is where they get their first eye-strain. Children have the example set them by their parents or business men, who read the daily papers on the trains. Children are great imitators, and when their attention is called to the evil, quote their parents' example, and they follow it. No wonder each generation is growing more effeminate.

The light in sick rooms should never fall directly on the eyes, nor should the rooms be either too dark or too light.

The Esquimaux and Indians long ago noted the fact that sunlight reflected from freshly fallen snow would soon cause blindness.

The natives of northern Africa blacken themselves around the eyes to prevent ophthalmia from the glare of the hot sand. In Fiji the natives, when they go fishing, blacken their faces. My friend, Dr. Bartelott, presented me with a pair of eye protectors, which he brought from Alaska. The natives use them to protect themselves from snow blindness. These snow spectacles, or snow eyes, as they are called, are usually made out of pine wood, which is washed upon their shores, drift wood from southern climes.

The posterior surface is deeply excavated, to prevent its obstructing the free motion of the eye lids; on each side a notch is cut at the lower margin to allow a free passage for the tears. The upper margin of the front surface is more prominent than the under, to act as a shade to the eyes. The inner surface is blackened to absorb the excessive light. The openings are horizontal slits. The eyes are thus protected from the dazzling effect of the light.

My friend, Dr. Grady, of Omaha, communicated to me a history of three hunters who almost lost their eyesight by too long exposure to the bright rays of the sun falling on snow.

The abuse of tobacco leads to impairment of vision in the growing youth. Cigarette smoking is an evil. I am inclined to believe that the poison inhaled arrests the growth of boys; surely it prevents a mental development, and, when carried to excess, affects vision more by lessening the power of nerve conduction than acting directly on the eye.

It is not the one cigarette which the boy smokes that does the harm, but it is the one, two, or three packages smoked daily. This excessive smoking thoroughly perverts all the functions which should be at their best to aid this growing youth. First we have failing digestion, restless nights, suspension of growth, lack of mental development, the loss of nerve tone, loss of the power of accommodation in vision, failing sight, headaches, enfeeblement of the heart. Let a man who is a habitual smoker of cigars attempt to smoke even one package of cigarettes and he will complain of nausea, dry throat, and loss of appetite. If a strong man is so much affected by this poison, how much less can a boy resist the inroads of such poisons? In Germany the law forbids the sale of cigarettes to growing boys. New York State has a similar law, and why should our own or any other State be behind in passing prohibitory laws against this evil?—and this is a growing evil.

I have never seen a case of tobacco amblyopia in boyhood, but such a condition is not infrequent in adults. In boys the action of nicotine acts especially upon the heart, the impulse is rendered weaker and intermittent, and many young boys lay the seeds of organic disease which sooner or later culminates fatally. Boys should be prohibited from smoking, first by their parents, second by law, but not such laws whose enforcement is a failure, third by placing a heavy fine upon dealers who sell to minors. The pernicious evil of intoxication is no less an evil upon the nervous system of a youth than is the habit of cigarette smoking, but, fortunately, this habit is less common. Having traced from aboriginal man to the present civilized individual the cause of his myopia, what must we do to prevent a further deterioration of vision? Unfortunately, the physician of our country is not, as I am told, like the Japanese physician. Our medical men are called to attend people who are ill and to try to get them well—the Japanese physician is paid only to keep his patients in health.

The first effort parents should make is to see that their children have plenty of outdoor exercise. Good, warm clothing in winter, and light texture cloth in summer. A great difference of opinion exists as to the age at which a child should begin its studies. I feel sure that the boy who commences his studies at ten will far outrun the one who commences study at six. Every child should commence his lessons in the best kindergarten, the nursery. Let object lessons be his primer—let him be taught by word of mouth—then, when his brain is what it should be for a boy of ten, his eyes will be the better able to bear the fatigue of the burdens which will be forced upon him. Listen to what Milton has left on record as a warning to those young boys or girls who insist upon reading or studying at night with bad illumination.

"My father destined me, from a child, for the pursuits of polite learning, which I prosecuted with such eagerness that, after I was twelve years old, I rarely retired to bed, from my lucubrations, till midnight. This was the first thing which proved pernicious to my eyes, to the natural weakness of which were added frequent headaches."

Milton went blind when comparatively a young man, and it was always to him a great grief. Galileo, the great astronomer, also went blind by overwork. It was written of him, "The noblest eye which ever nature made is darkened—an eye so privileged, and gifted with such rare powers, that it may truly be said to have seen more than the eyes of all that are gone, and to have opened the eyes of all that are to come."

When the defect of far sightedness or near sightedness exists, we have but one recourse—*spectacles.*

Some time ago I published, in the *Medical and Surgical Reporter*, an article on the history of spectacles. The widespread interest which this paper created has stimulated me to continue the research, and since this article appeared I have been able to gather other additional historical data to what has been described as an invention for "poor old men when their sight grows weak."

The late Wendell Phillips, in his lecture on the "Lost Arts," speaks of the ancients having magnifying glasses. "Cicero said that he had seen the entire *Iliad*, which is a poem as large as the New Testament, written on a skin so that it could be rolled up in the compass of a nut shell;" it would have been impossible either to have written this, or to have read it, without the aid of a magnifying glass.

In Parma, a ring 2,000 years old is shown which once belonged to Michael Angelo. On the stone are engraved the figures of seven women. You must have the aid of a glass in order to distinguish the forms at all. Another *intaglio* is spoken of—the figure is that of the god Hercules; by the aid of glasses, you can distinguish the interlacing muscles and count every separate hair on the eyebrows. Mr. Phillips again speaks of a stone 20 inches long and 10 wide containing a whole treatise on mathematics, which would be perfectly illegible without glasses. Now, our author says, if we are unable to read and see these minute details without glasses, you may suppose the men who did the engraving had pretty strong spectacles.

"The Emperor Nero, who was short sighted, occupied the imperial box at the Coliseum, and, to look down into the arena, a space covering six acres, the area of the Coliseum, was obliged, as Pliny says, to look through a ring with a gem in it—no doubt a concave glass—to see more clearly the sword play of the gladiators. Again, we read of Mauritius, who stood on the promontory of his island and could sweep over the sea with an optical instrument to watch the ships of the enemy. This tells us that the telescope is not a modern invention."

Lord Kingsborough, speaking of the ancient Mexicans, says: "They were acquainted with many scientific instruments of strange invention, whether the telescope may not have been of the number is uncertain, but the thirteenth plate of *Dupaix's Monuments*, part second, which represents a man holding something of a similar nature to his eye, affords reason to suppose that they knew how to improve the powers of vision.

Our first positive knowledge of spectacles is gathered from the writings of Roger Bacon, who died in 1292.* Bacon says: "This instrument (a plano-convex glass or large segment of a sphere) is useful to old men and to those who have weak eyes, for they may see the smallest letters sufficiently magnified."

Alexander de Spina, who died in 1313, had a pair of spectacles made for himself by an optician who had the secret of their invention. De Spina was so much pleased with them that he made the invention public.

Monsieur Spoon fixes the date of the invention between 1280 and 1311. In a manuscript written in 1299 by Pissazzo, the author says: "I find myself so pressed by age that I can neither read nor write without those glasses they call spectacles, lately invented, to the great advantage of poor old men when their sight grows weak." Friar Jordan, who died in Pisa in 1311, says in one of his sermons, which was published in 1305, that "it is not twenty years since the art of making spectacles was found out, and is indeed one of the best and most necessary inventions in the world." In the fourteenth century spectacles were not uncommon, and Italy excelled in their manufacture. From Italy the art was carried into Holland, then to Nuremberg, Germany. In a church in Florence is a fresco representing St. Jerome (1480). Among the several things represented is an inkhorn, pair of scissors, etc. We also find a pair of spectacles, or *pince-nez*—the glasses are large and round and framed in bone.

It was not until 1575 that Maurolicus, of Messina, pointed out the cause of near sightedness and far sightedness and explained how concave glasses corrected the former and convex glasses the latter defect.

In the wake of advanced education stalks the spectacle age. Any one watching a passing crowd cannot fail but note the great number of people wearing spectacles. Unfortunately it is not limited to adults, but our youths of both sexes go to make up this army of ametropes.

At what age should children first wear glasses? This is a much debatable question. Where there is simply a defect of vision I should never prescribe a pair of glasses for a child under ten years of age. A child under this age runs many risks of injury to the eyeball by accident to the glasses, and to cut the eye with glass is a very serious affair. Rather let a child go without study, or even with impaired vision, than run the risk of a permanent loss of sight.

Another source of evil I must call your attention to, and that is the indiscriminate use of glasses given by itinerant venders of spectacles who claim a thorough knowledge of the eye, who make examination free, but charge double price for glasses.

Persons, before submitting themselves into the hands of opticians, should know that they are not suffering from any incipient disease of their eyes. I do not, for a moment, claim that a practical optician cannot give you a pair of glasses which will make you see—he does nothing more than hand you a number of pairs of glasses and you select the one pair which you think answers the purpose. How can any one but a medical man know that the impairment of vision does not arise from diminished sensibility of the retina? If so, the glasses just purchased, which may be comfortable for a time, may cause an irreparable loss of vision. Every ophthalmic surgeon will tell you that he has had a number of such cases. Do not be misguided by purchasing cheap spectacles. Glasses advertised as having "remarkable qualities" are always to be passed by. They have "remarkable qualities;" they always leave the person wearing them worse at the end of a few months. Whenever an eye finds relief in a shaded or colored glass, something is going wrong with the interior of that eye. Seek advice, but do not trust the eyes of yourself, much less those of your children, in the hands of the opticians who advertise their examinations free.

Such individuals should be brought before a tribunal and the matter sifted as to whether the sense of sight is less to be taken care of than if that same patient were ill with pneumonia and a druggist were to prescribe remedies which might or might not aid this patient. If one man must comply with the law, why should not the other? Our medical colleges are lengthening the course of studies; the advances in the various departments of science demand this. It is by the aid of the ophthalmoscope that many obscure diseases are diagnosed, and while it is impossible for every young man who obtains a diploma to become thoroughly proficient in the use of this instrument, yet the eye shows to him many conditions which guide him to the road of successful treatment. Think of a case of optic neuritis—inflammation of the optic nerve—going to an optician and fitting one set of glasses after another until the patient suddenly discovers that blindness is

* *Med. and Surg. Reporter.*

inevitable. Many individuals, and very intelligent ones at that, think that so long as a glass makes them see, that is all they need. When we know that scarcely two eyes are alike, we can at once feel that it is very important that each eye should be properly adjusted for a glass; by this we are sure of having comfort in reading and preserving vision.

There is a very important defect in vision which should be detected as early in life as possible, and that is color blindness. The boy who is a color blind will always remain a color blind, and as forty in every 1,000 of the male sex are color blind, it is essential that they know their defect, and train their course accordingly. It would be to the advantage of all boys to undergo such an examination once in their school life; a color blind would be useless where the selection of color entered into his life work. If a boy had a talent for drawing or engraving, and were color blind, he would make a success of his life, whereas if he would attempt to mix paints of different colors he would be a failure.

I shall not dwell upon the scientific part of color blindness, nor discuss either the Young-Helmholtz or the Hering theories of color defect, but shall deal with its practical use in everyday life.

Until the year 1853, very little was known about color blindness, and much less written about it.

Dr. George Wilson, in 1853, wrote several articles, which were published in the *Edinburgh Monthly Journal of Medical Science*. These articles created such an interest in the scientific world that Dr. Wilson brought out a book, entitled "Researches on Color Blindness," two years later. So thoroughly did Dr. Wilson sift this subject that no writer up to the present day has added anything practical to what was then known.

Dr. Wilson writes in his preface: "The most practical relation of color blindness is that which it has to railway and ship signals." He further states: "The professions for which color blindness most seriously disqualifies are those of the sailor and railway servant, who have daily to peril human life and property on the indication which a colored flag or a lamp seems to give."

Dr. Bickerton, in an article on this same subject, speaking of the careless way in which lights were used on ships at sea, says: "Until the year 1852, there were no definite rules regarding the carrying of lights at night by vessels at sea. . . . At this time the subject of color blindness had not awakened the attention of practical observers, and had the fact been known that between three and four per cent. of the whole male population are color blind, some other mode might have been devised to indicate the positions of vessels at night than by showing red and green lights."

If it is so very important to have sailors with good color perception, where, at least, four men are on the lookout, how much more important is it to have our engine drivers with perfect color perception, where one man alone watches the signal of safety or danger.

The growth of our railway system is constantly increasing. We have to-day probably 150,000 men employed in this service. The boys attending public schools to-day in a few years will have to fill the ranks of these men. How important for these boys to know that they have not this defect. If the forty boys in every 1,000 are found, what is to be done with them? The engraver, the wood cut engraver, the etcher, all wish apprentices. I am also informed that these occupations pay well. It requires talent to fill them, and here is an opening for the color blind. Hear what a color blind writes: * "I beg to offer some particulars of my own case, trusting it may be of use to you. I am an engraver, and strange as it may appear, my defective vision is, to a certain extent, a useful and valuable quality. Thus, an engraver has two negative colors to deal with, *i. e.*, white and black. Now, when I look at a picture, I see it only in white and black, or light and shade, and any want of harmony in the coloring of a picture is immediately made manifest by a corresponding discord in the arrangement of its light and shade or, as artists term it, the *effect*. I find at times many of my brother engravers in doubt how to translate certain colors of pictures which to me are matters of decided certainty and ease. Thus, to me it is valuable." Having already spoken about the importance of having all boys undergo an examination for color blindness once in their school lives, we have two very good reasons for making this suggestion.

First, prevent a boy following a trade or occupation where he is incapacitated, and, secondly, let him be trained for a certain trade or occupation when the defect exists. The savage races possess the perception of color to a greater degree than do civilized races. I have just concluded an examination of 250 Indian children; 100 were boys. Had I selected 100 white boys from various parts of the United States I would have found at least five color blinds; among the Indian boys I did not find a single one. Some years ago I examined 250 Indian boys and found two color blind, a very low percentage when compared with the whites. Among the Indian girls I did not find any. When we know that only two females in every 1,000 among whites are color blind, it is not surprising that I did not find any examples among the Indian girls.

The usual tests for color blindness are the matching of wools; the common error the color blind falls into is matching a bright scarlet with a green. On one occasion, a color blind gentleman found fault with his wife for wearing, as he thought, a bright scarlet dress, when in point of fact she was wearing a bright green. Another color blind who was very fond of drawing, once painted a red tree in a landscape without being aware that he had done so.

Among the whites it affects all classes. It is found as relatively common among the intelligent as the illiterate, and unfortunately, up to the present, we have not discovered any remedy for this defect.

Without quoting many instances where a color blind man was responsible for accidents at sea, I must quote a case where an officer on the watch issued an order to "port" his vessel, which, if his order had been carried out, would have caused a collision, and a probable serious loss of life.

The letter was written by Capt. Coburn, and is to be found in the *Mercantile Marine Reporter*, vol. xiv.

"The steamer Neera was on a voyage from Liverpool to Alexandria. One night, shortly after passing Gibraltar, at about 10.30 p. m., I went on the bridge, which was then in charge of the third officer, a man of about forty-five years of age, and who up to that time I had supposed to be a trustworthy officer, and competent in every way. I walked up and down the bridge until about 11 p. m., when the third officer and I almost simultaneously saw a light at about two points on the starboard bow. I at once saw it was a green light, and knew that no action was called for. To my surprise, the third officer called out to the man at the wheel, 'port,' which he was about to do, when I countermanded the order, and told him to steady his helm, which he did, and we passed the other steamer safely about half a mile apart. I at once asked the third officer why he had ported his helm to a green light on the starboard bow, but he insisted it was a red light which he had first seen. I tried him repeatedly after this, and although he sometimes gave a correct description of the color of the light, he was as often incorrect, and it was evidently all guesswork. On my return, I applied to have him removed from the ship, as he was, in my opinion, quite unfit to have charge of the deck at night, and this application was granted. After this occurrence I always, when taking a strange officer to sea, remained on the bridge with him at night until I had tested his ability to distinguish colors. I cannot imagine anything more dangerous or more likely to lead to fatal accidents than a color blind man on a steamer's bridge."

A similar experience is thus related by Capt. Heasley, of Liverpool: "After passing through the Straits of Gibraltar, the second officer, who had charge of the deck, gave the order to 'port,' much to my astonishment, for the lights to be seen about a point on the starboard bow were a masthead and green light, but he maintained that it was a masthead and red, and not until both ships were nearly abreast would he acknowledge his mistake. I may add that during the rest of the voyage I never saw him making the same mistake. As a practical seaman I consider a great many accidents at sea arise from color blindness."

Dr. Farquharson has brought this subject before the House of Commons in England and measures are being taken which will insure to the traveling public immunity from accidents at sea. I need not mention that the majority of railways of our country have a system of examinations which prevents a color blind entering their service.

Dr. Wilson makes the suggestion that he noticed a singular expression in the eyes of certain of the color blind difficult to describe. "In some it amounted to a startled expression, as if they were alarmed; in others, to an eager, aimless glance, as if seeking to perceive something but unable to find it; and in certain others to an almost vacant stare, as if their eyes were fixed upon objects beyond the limit of vision. The expression referred to, which is not at all times equally pronounced, never altogether leaves the eyes which it seems to characterize."

Dr. B. Joy Jeffries, of Boston, has recently written an article on this same topic, but unfortunately I have not his pamphlet at hand to quote his views on this subject.

In this lecture I have shown that the normal eye is far sighted. The mammalia have this kind of an eye; the Indian the same. The white man is fast becoming near sighted. The civilized Indian is also showing the effects of continuous near work; and now the question arises, What are we to do to prevent further deterioration of vision? The fault lies at our own doors. Let us try to correct these now existing evils, so that future generations will, instead of censuring us, thank us for our wisdom.

To aid in a feeble way for the protection of posterity I have formulated ten rules on the preservation of vision:

(1) Do not allow light to fall upon the face of a sleeping infant.

(2) Do not allow babies to gaze at a bright light.

(3) Do not send children to school before the age of ten.

(4) Do not allow children to keep their eyes too long on a near object, at any one time.

(5) Do not allow them to study much by artificial light.

(6) Do not allow them to use books with small type.

(7) Do not allow them to read in a railway carriage.

(8) Do not allow boys to smoke tobacco, especially cigarettes.

(9) Do not necessarily ascribe headaches to indigestion. The eyes may be the exciting cause.

(10) Do not allow the itinerant spectacle vender to prescribe glasses.

* Wilson, p. 27.

THE WATER MOLECULE.*

By A. GANSWINDT.

"WATER consists of one atom of oxygen and two atoms of hydrogen." This proposition will not be disputed in the least by the author; still, it may be profitable to indulge in a few stereo-chemic speculations as to the nature of the water molecule and to draw the inevitable conclusions.

From the time of the discovery, some 110 years ago, that water is a compound body, made up of oxygen and hydrogen, the notion prevailed up to within a quarter of a century that it was composed of even equivalents of the elements named, and all but the youngest students of chemistry well remember how its formula was written HO, the atomic weight of oxygen being expressed by 8, making the molecular weight of water ($H = 1 + O = 8$) 9. But the vapor density of water, referred to air, is 0·625, and this number multiplied by the constant 28·87, gives 18 as the molecular weight of water, or exactly twice that accepted by chemists. This discrepancy led to closer observations, and it was eventually found that in decomposing water, by whatever method (excepting only electrolysis), not more than the eighteenth part in hydrogen of the water decomposed was ever obtained, or, in other words, only just one-half the weight deducible from the formula $HO = 9$. The conclusion was irresistible that in a water molecule two atoms of hydrogen must be assumed, and, as a natural sequence, followed the doubling of the molecular weight of water to 18, represented by the modern formula H_2O.

Both the theory and the practice of substitution enable us to further prove the presence of two hydrogen atoms in a water molecule. Decomposing water by sodium, only one-half of the hydrogen contained is eliminated, the other half, together with all of the oxygen, uniting with the metal to form sodium hydroxide, $H_2O + Na = H + NaHO$. Doubling the amount of sodium does not alter the result, for decomposition according to the equation $H_2O + 2\,Na = H_2 + Na_2O$ never happens. Introducing the ethyl group into the water molecule and reacting under appropriate conditions with ethyl iodide upon water, the ethyl group displaces one atom of hydrogen, and, uniting with the hydroxyl residue, forms ethyl alcohol, thus: $H_2O + C_2H_5I = C_2H_5{\cdot}OH + HI$. Halogens do not act directly on water, hence we may not properly speak of halogen substitution products. By the action, however, of phosphorus haloids on water an analogous splitting of the water molecule is again observed, one-half of the hydrogen uniting with the halogen to form an acid, the hydroxyl residue then forming a phosphorus compound, thus: $PCl_3 + 3\,H_2O = 3\,HCl + P(OH)_3$.

Now these examples, which might readily be multiplied, prove not only the presence of *two* hydrogen atoms in the water molecule, but they further demonstrate that these two atoms *differ from each other* in respect to their form of combination and power of substitution. The two hydrogen atoms are certainly not of equal value, whence it follows that the accepted formula for water: $\begin{matrix}H\\H\end{matrix}\!>O$, or as preferred by some: H–O–H, is not in conformity with established facts. Expressed as here shown, both hydrogen atoms are assigned equal values, when in fact only *one of the atoms is united to oxygen in form of hydroxyl*, while the second is loosely attached to the univalent hydroxyl group. Viewed in this light, water then is decomposed according to the equation: $H_2O = H + (OH)$, never in this manner: $H_2O = 2H + O$. Hence, water must be considered as a combination of one hydrogen atom with one molecule of hydroxyl, expressed by the formula H(OH), and it is this atom of hydrogen *not* united to oxygen which is eliminated in the generation of oxygen or substituted by metals and alkyl groups. The hydrogen in the hydroxyl group cannot be substituted, excepting it be the entire group as such; this is proved by the action of the halogens, in their phosphorus compounds, upon water, when the halogen takes the place of the hydroxyl group, but never that of the hydrogen.

Now as to some logical deductions from the foregoing considerations. Hydrogen is by many looked upon as a true metal. This theory cannot be directly proved by the above, but it is certainly greatly strengthened thereby. To compare. Hydrogen is a powerful reducing agent; it is similarly affected by the halogens, the hydroxyl group, the acid radicals, oxygen and sulphur; hydrogen and members of the univalent alkali metals group are readily interchangeable; it forms superoxides analogous to the metals; its analogy to the alkali metals as exhibited in the following:

$$H \quad H(OH) \quad HCl \quad HNO_3 \quad H_2SO_4 \quad H_2S \quad H_2O_2$$
$$K \quad K(OH) \quad KCl \quad KNO_3 \quad Na_2SO_4 \quad Na_2S \quad K_2O$$

But if we consider hydrogen as a gasiform metal, we naturally arrive at the conclusion that *water is the hydroxide of this gasiform metal*, that is *hydrogen hydroxide*, while gaseous hydrochloric and hydrosulphuric acids would be looked upon as respectively the chloride and the sulphide of the metal hydrogen. This would then lead to curious conclusions concerning the hydroxyl group. This group would, by this theory, become an oxygenated metal radical similar to the hypothetical bismuthyl and uranyl, and yet one in which the metallic character has disappeared as completely as in the ferrocyanic group.

An entirely new light is shed by this view upon the composition of hydrogen peroxide, which would be looked at as two free hydroxyl groups joined together thus: (OH)—(OH), analogous to our di-ethyl, diphenyl, dicyanogen, etc. Considered as "dihydroxyl, it would explain the instability of this compound.

The ethers proper would also be placed in a new light by this new conception of the constitution of the water molecule. The hydrogen in the hydroxyl group, as is known, may be substituted by an alkyl group. For instance, an alkyl may be substituted for the hydroxyl hydrogen in an alcohol molecule, when an ether results. According to the new theory this ether will no longer be considered as two alkyl groups connected by an oxygen atom, but as a compound built up on the type of water by the union of an alkyl group and an alkoxyl group. Thus ethylic ether would not be represented by $\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\!>O$, as heretofore, but by the formula $C_2H_4(OC_2H_5)$, which is ethyl-ethoxol. Acetone would admit of a similar explanation.

Finally the assumption of dissimilarity in character of the hydrogen atoms in the water molecule possibly may lead to the discovery of a number of unlooked for isomerides.

Thus, by appropriate methods, it ought to become possible to introduce the alkyl groups solely into the hydroxyl group (instead of into the place of the loosely attached H-atom). In that case chemists might arrive at an isomeride of methyl alchol of the formula $H.(OCH_3)$, or at methoxyl hydride, a compound not alcoholic in character, or at a nitroxyl hydride, $H(ONO_2)$, not of an acidic nature. Oxychlorides would be classed with this latter category, that is, they would be looked on as water in which the free hydrogen atom has been substituted by the metal, and the hydrogen atom of the hydroxyl by chlorine. This example, indeed, furnishes a most characteristic illustration of our theory. In the case just now assumed we arrive at the oxychloride; when, however, the metal and chlorine change places in the water molecule, the isomeric hypochlorous salts are the result. It is true that such cases of isomerism are as yet unknown, but we do know that certain metals, in our present state of knowledge, yield oxychlorides only, while others only form hypochlorous salts. This condition also explains why hypochlorites still possesses the bleaching power of chlorine, while the same is not true of oxychlorides. However, it seems needless to multiply examples in further illustration of the theory.

* Translated from the *Pharmaceutische Centralhalle*, by A. G. Vogeler.—*Western Druggist*.

THE FORMATION OF STARCH IN LEAVES.

In 1759, Bonnet, a Genevese naturalist, remarked that leaves immersed in water became covered in the sun with small bubbles of a gas that he compared to small pearls. In 1772, Priestley, after discovering that the sojourn of animals in a confined atmosphere renders it irrespirable, investigated the influence of plants placed in the same conditions, and he relates, in these words, the discovery that he made on the subject:

"I put a sprig of mint in a quantity of air in which a candle had ceased to burn, and I found that, ten days later, another candle was able to burn therein perfectly well." It is to him, therefore, that is due the honor of having ascertained that plants exert an action upon the atmosphere contrary to that exerted by animals. Priestley, however, was not completely master of his fine experiment; he was ignorant of the fact, notably, that the oxygen is disengaged by plants only as long as they are under the influence of light.

This important discovery is due to Ingenhouse. Finally, it was Sennebier who showed that oxygen is obtained from leaves only when carbonic acid has been introduced into the atmosphere where they remain. Later on, T. De Saussure and Boussingault inquired into the conditions most favorable to assimilation. Boussingault demonstrated, in addition, that the volume of carbonic acid absorbed was equal to that of the oxygen emitted. Now we know, through a common chemical experiment, that carbonic acid contains its own volume of oxygen. It was supposed, then, that carbonic acid was decomposed by sunlight into carbon and oxygen. Things, however, do not proceed so simply. In fact, it is certain that, before the complete decomposition into carbon and oxygen, there comes a moment in which there is oxygen on the one hand and oxide of carbon ($CO^2 = O + CO$) on the other.

The decomposition, having reached this point, can go no further, for the oxide of carbon is indecomposable by leaves, as the following experiment proves.

If we put phosphorus and some leaves into an inert gas, such as hydrogen, we in the first place observe the formation of the white fumes of phosphoric acid due to the oxidation of the phosphorus by the oxygen contained in the leaves. This phosphoric acid dissolves in the water of the test glass and the latter becomes transparent again. If, now, we introduce some oxide of carbon, we remark in the sun no formation of phosphoric acid, and this proves that there is no emission of oxygen.

This latter hypothesis of the decomposition of carbonic acid into a half volume of vapor of carbon and one volume of oxygen being rejected, the idea occurred to consider the carbonic acid in a hydrated state and to write it CO^2HO.

In this case, we should have by the action of chlorophyl: $2CO^2HO$ (carbonic acid) $= 4O$ (oxygen) $+ C^2H^2O^2$ (methylic aldehyde).

This aldehyde is a body that can be polymerized, that is to say, is capable of combining with itself a certain number of times to form complexer bodies, especially glucose. This formation of a sugar by means of methylic aldehyde is not a simple hypothesis, since, on the one hand, Mr. Loew has executed it by starting from methylic aldehyde, and, on the other, we find this glucose in leaves by using Fehling's solution.

The glucose formed, it is admissible that a new polymerization with elimination of water produces starch. The latter, in fact, through the action of an acid, is capable of regenerating glucose.

It may, therefore, be supposed that the decomposition of carbonic acid by leaves brings about the formation of starch through the following transformations: (1) The decomposition of the carbonic acid with emission of oxygen and production of methylic aldehyde; (2) polymerization of methylic aldehyde and formation of glucose; (3) combination of several molecules of glucose with elimination of water; formation of starch.

Starch is thus the first stable product of chlorophylian activity. Is there, in fact, starch in leaves? It is easy to reveal its presence by the blue coloration that it assumes in contact with iodine in a leaf bleached by boiling alcohol.

Mr. Deherain has devised a nice method of demonstrating that this formation of starch, and consequently the decomposition of carbonic acid, can occur only under the influence of sunlight. He pointed it out to us in his course of lectures at the School of Grignon, and asked us to repeat the experiment. We succeeded, and now make the *modus operandi* known to our readers.

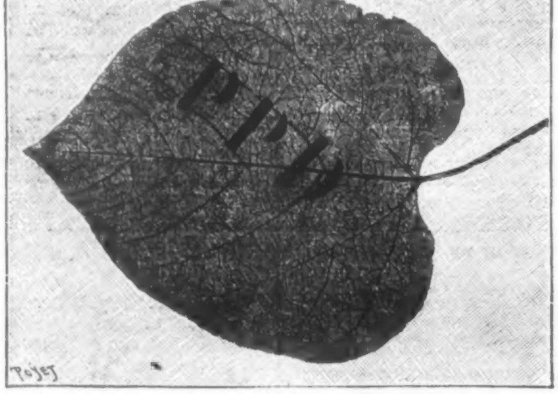
The leaf that gave the best result was that of the *Aristolochia Sipho*. The leaf, adherent to the plant, is entirely inclosed between two pieces of perfectly opaque black paper. That which corresponds to the upper surface of the limb bears cut-out characters, which are here the initials of Mr. Deherain. The two screens are fastened to the leaf by means of a mucilage of gum arabic that will easily cede to the action of warm water at the end of the experiment.

The exposure is made in the morning, before sunrise. At this moment, the leaf contains no starch; that which was formed during the preceding day has emigrated during the night toward the interior of the plant.

After a few hours of a good insolation, the leaf is picked off. Then the gum which holds the papers together is dissolved by immersion in warm water. The decolorizing is easily effected through boiling alcohol, which dissolves the chlorophyl and leaves the leaf slightly yellowish and perfectly translucent.

There is nothing more to do then but dip the leaf in tincture of iodine. If the insolation has been good, and if the screens have been well gummed so that no penumbra has been produced upon the edge of the letters, a perfectly sharp image will be instantly obtained. The excess of iodine is removed by washing with alcohol and water, and the leaf is then dried and preserved between the leaves of a book.

It is well before decolorizing the leaf to immerse it in a solution of potassa; the chlorophylian starch then swells and success is rendered easier.—*Lartigue and Malpeaux, in La Nature.*



DEMONSTRATION THAT STARCH IS FORMED IN LEAVES ONLY AT THE POINTS TOUCHED BY LIGHT.

STANDARDS AND METHODS FOR THE POLARIMETRIC ESTIMATION OF SUGARS.*

Section 1, paragraph 231, of the act entitled "An act to reduce revenue and equalize duties on imports and for other purposes," approved October 1, 1890, provides:

"231. That on and after July 1, eighteen hundred and ninety-one, and until July 1, nineteen hundred and five, there shall be paid, from any moneys in the Treasury not otherwise appropriated, under the provisions of section three thousand six hundred and eighty-nine of the Revised Statutes, to the producer of sugar testing not less than ninety degrees by the polariscope, from beets, sorghum, or sugar cane grown within the United States, or from maple sap produced within the United States, a bounty of two cents per pound; and upon such sugar testing less than ninety degrees by the polariscope, and not less than eighty degrees, a bounty of one and three-fourth cents per pound, under such rules and regulations as the Commissioner of Internal Revenue, with the approval of the Secretary of the Treasury, shall prescribe."

It is the opinion of this Commission that the expression "testing . . . degrees by the polariscope," used with reference to sugar in the act, is to be considered as meaning the percentage of pure sucrose the sugar contains, as ascertained by polarimetric estimation.

It is evident that a high degree of accuracy is necessary in the examination of sugars by the Bureau of Internal Revenue, under the provisions of this act, inasmuch as the difference of one-tenth of one per cent. in the amount of sucrose contained in a sugar may, if it is on the border line of 80°, decide whether the producer is entitled to a bounty of 1¾ cents per pound (an amount nearly equivalent to the market value of such sugar) or to no bounty whatever. It is desirable, therefore, that the highest possible degree of accuracy should be secured in the work, for while many sugars will doubtless vary far enough from either of the two standard percentages fixed upon in the act, viz., 80° and 90°, to admit of a wide margin of error without material consequences, yet a considerable proportion will approximate to them so closely that a difference of a few tenths of a degree in the polarization will change the classification of the sugar.

A very high degree of accuracy may be obtained in the optical estimation of sugars, if the proper conditions are observed. Such conditions are (1) accurately graded and adjusted instruments, weights, flasks, tubes, etc.; (2) skilled and practiced observers; (3) a proper arrangement of the laboratories in which the work is performed; and (4) a close adherence to the most approved methods of manipulation.

On the other hand, if due observance is not paid to these conditions, the sources of error are numerous, and inaccurate results inevitable.

We will endeavor to point out in this report the best means of meeting the proper conditions for obtaining the highest degree of accuracy consistent with fairly rapid work. It would be manifestly impossible to observe so great a refinement of accuracy in this work as would be employed in exact scientific research. This would be unnecessary for the end in view, and impossible on account of the amount of time that would be required.

I.—INSTRUMENTS AND APPARATUS.

It is of the greatest importance that the polariscopes and all apparatus used in the work shall be carefully and accurately adjusted and graduated, and upon a single and uniform system of standardization. Recent investigations of the polarimetric work done in the customs branch of the Treasury Department have shown that a very considerable part of the want of agreement in the results obtained at the different ports was due to a lack of uniformity in the standardization of the instruments and apparatus.

(*a.*) *The Polariscope.*—There are many different forms of this instrument used. Some are adapted for use with ordinary white light, and some with monochromatic light, such as sodium ray. They are graduated and adjusted upon various standards, all more or less arbitrary. Some, for example, have their scales based upon the displacement of the polarized ray produced by a quartz plate of a certain thickness; others upon the displacement produced by an arbitrary quantity of pure sucrose, dissolved and made up to a certain volume and polarized in a certain definite length of column. It would be very desirable to have an absolute standard set for polariscopic measurements, to which all instruments could be referred, and in the terms of which all such work could be stated. This commission has information that an investigation is now in progress under the direction of the German imperial government, having for its end and purpose the determination of such data as will serve for the establishment of an absolute standard. When this is accomplished it can easily be made a matter of international agreement, and all future forms of instruments be based upon it. This commission would suggest that the attention of the proper authorities should be called to the desirability of official action by this government with a view to co-operation with other countries for the adoption of international standards for polarimetric work. Until this is done, however, it will be necessary for the Internal Revenue Bureau to adopt, provisionally, one of the best existing forms of polariscope, and by carefully defining the scale of this instrument, establish a basis for its polarimetric work which will be a close approximation to an absolute standard, and upon which it can rely in case of any dispute arising as to the results obtained by the officers of the bureau.

For the instrument to be provisionally adopted by the Internal Revenue Bureau, this commission would recommend the "half shadow" instrument made by Franz Schmidt & Haensch, Berlin. This instrument is adapted for use with white light illumination, from coal oil or gas lamps. It is convenient and easy to read, requiring no delicate discrimination of colors by the observer, and can be used even by a person who is color blind.

This form of instrument is adjusted to the Ventzke scale, which, for the purposes of this report, is defined to be such that 1° of the scale is the one hundredth part of the rotation produced in the plane of polarization of white light in a column 200 mm. long by a standard solution of chemically pure sucrose at 17·5° C. The standard solution of sucrose in distilled water being such as to contain, at 17·5° C. in 100 c. c., 26·048 grms. of sucrose.

In this definition the weights and volumes are to be considered as absolute, all weighings being referred to a vacuum.

The definition should properly be supplemented with a statement of the equivalent circular rotation in degrees, minutes, and seconds that would be produced by the standard solution of sugar used to read 100° on the scale. This constant is now a matter of investigation, and it is thought best not to give any of the hitherto accepted values. When this is established, it is recommended that it be incorporated in a revision of the regulations of the internal revenue relative to sugar, in order to make still more definite and exact the official definition of the Ventzke scale.

The instruments should be adjusted by means of control quartz plates, three different plates being used for complete adjustment, one reading approximately 100° on the scale, one 90°, and one 80°.

These control quartz plates should have their exact values ascertained in terms of the Ventzke scale by the office of weights and measures by comparison with the standard quartz plates in possession of that office, in strict accordance with the foregoing definition, and should also be accompanied by tables giving their values for temperatures from 10° to 35°.

(*b.*) *Weights.*—The weights used should be of solid brass, and should be standardized by the office of weights and measures.

(*c.*) *Flask.*—The flasks used should be of such a capacity as to contain at 17·5° C. 100·06 cubic centimeters, when filled in such a manner that the lowest point of the meniscus of the surface of the liquid just touches the graduation mark. The flasks will be standardized to contain this volume in order that the results shall conform to the scale recommended for adoption without numerical reduction of the weighings to vacuo. They should be calibrated by the office of weights and measures.

(*d.*) *Tubes.*—The tubes used should be of brass or glass, 200 and 100 millimeters in length, and should be measured by the office of weights and measures.

(*e.*) *Balances.*—The balances used should be sensitive to at least one milligramme.

II.—SKILLED OBSERVERS.

The commission recommends that the work of polarizing sugars be placed in the hands of chemists, or at least of persons who are familiar with the use of the polariscope and have some knowledge of the theory of its construction and of chemical manipulations. To this end we would suggest that applicants for positions where such work is to be done should be obliged to undergo a competitive examination in order to test their fitness for the work that is to be required of them.

III.—ARRANGEMENT OF LABORATORIES.

The arrangement of the rooms in which polarizations are performed has an important bearing upon the accuracy of the results obtained.

Polariscopic observations are made more readily and

* Report to the United States Internal Revenue Department by C. A. Crampton, Chemist of U. S. Internal Revenue; H. W. Wiley, Chief Chemist of U. S. Department of Agriculture; and O. H. Tittmann, Assistant in Charge of Weights and Measures, U. S. Coast and Geodetic Survey.

accurately if the eye of the observer is screened from diffused light; therefore, a partial darkening of the room, which may be accomplished by means of curtains or hangings, is an advantage. On the other hand, the temperature at which the observation is made has a very considerable influence upon the results obtained, so that the arrangements for darkening the room must not be such as will interfere with its proper ventilation. Otherwise the heat from the lamps used, if confined within a small room, will cause considerable variations in the temperature of the room from time to time.

The proper conditions will best be met, in our opinion, by placing the lamps either in a separate room from that in which the instruments are, and perforating the wall or partition between the two rooms for the light to reach the end of the instruments, or in a ventilated hood with the walls perforated in a like manner. By lining the wall or partition on both sides with asbestos paper, and inserting a plate of plane glass in the aperture through which the light passes, the increase of temperature from the radiation of the lamp will be still further avoided. With the lamps separated from the instruments in this manner, the space in which the instruments are contained is readily darkened without much danger of its temperature being unduly raised.

Some light, of course, is necessary for reading the scales, and if artificial light is employed for this purpose, the sources chosen should be such that as little heat as possible will be generated by them. Small incandescent electric lights are best for such purpose. Refinements of this kind cannot always be used, of course, but the prime requisite with reference to the avoidance of temperature errors is that all operations—filling the flasks and tubes, reading the solutions, controlling the instrument with standard quartz plates, etc.—should be done at one and the same temperature, and that this temperature be a constant one, that is, not varying greatly at different hours of the day. For example, the room should not be allowed to become cold at night, so that it is at low temperature in the morning when work is begun, and then rapidly heated up during the day. The polariscope should not be exposed to the direct rays of the sun during part of the day, and should not be near artificial sources of heat, such as steam boilers, furnaces, flues, etc.

The tables upon which the instruments stand should be level.

IV.—METHODS OF MANIPULATION.

The methods of manipulation used in the polarization of sugar are of prime importance. They consist in weighing out the sugar, dissolving it, clarifying the solution, making it up to standard volume, filtering, filling the observation tube, regulating the illumination, and making the polariscopic reading.

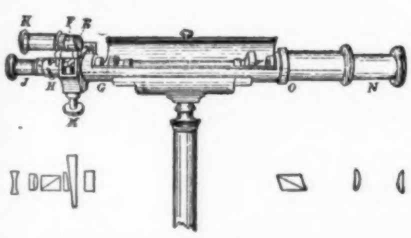
The proper conduct of these processes, in connection with the use of accurately graduated apparatus, is the only surety against the numerous sources of error which may be encountered. Different sugars require different treatment in clarification, and much must necessarily be left to the judgment and experience of the operator.

The following directions are based upon various official procedures such as the one used in the United States custom houses, the method prescribed by the German government, etc. They embody also the result of recent research in regard to sources of error in polarimetric estimation of sugar:

DIRECTIONS FOR THE POLARIZATION OF SUGAR.

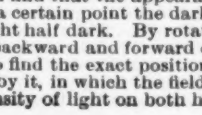
1.—*Description of Instrument and Manner of Using.*

The instrument employed is known as the half shadow apparatus of Schmidt and Haensch. It is shown in the following cut.



The tube N contains the illuminating system of lenses and is placed next to the lamp; the polarizing prism is at O, and the analyzing prism at H. The quartz wedge compensating system is contained in the portions of the tube marked F, E, G, and is controlled by the milled head M. The tube J carries a small telescope, through which the field of the instrument is viewed, and just above is the reading tube K, which is provided with a mirror and magnifying lens for reading the scale.

The tube containing the sugar solution is shown in position in the trough between the two ends of the instrument. In using the instrument the lamp is placed at a distance of at least 200 mm. from the end; the observer seats himself at the opposite end in such a manner as to bring his eye in line with the tube J. The telescope is moved in or out until the proper focus is secured, so as to give a clearly defined image, when the field of the instrument will appear as a round, luminous disk, divided into two halves by a vertical line passing through the center, and darker on one half of the disk than on the other. If the observer, still looking through the telescope, will now grasp the milled head M and rotate it, first one way and then the other, he will find that the appearance of the field changes, and at a certain point the dark half becomes light, and the light half dark. By rotating the milled head delicately backward and forward over this point he will be able to find the exact position of the quartz wedge operated by it, in which the field is neutral, or of the same intensity of light on both halves.



The three different appearances presented by the field are best shown in the above diagram.

With the milled head set at the point which gives the appearance of the middle disk as shown, the eye of the observer is raised to the reading tube, K, and the position of the scale is noted. It will be seen that the scale proper is attached to the quartz wedge, which is moved by the milled head, and attached to the other quartz wedge is a small scale called a vernier which is fixed, and which serves for the exact determination of the movable scale with reference to it. On each side of the zero line of the vernier a space corresponding to nine divisions of the movable scale is divided into ten equal parts. By this device the fractional part of a degree indicated by the position of the zero line is ascertained in tenths; it is only necessary to count from zero, until a line is found which makes a continuous line with one on the movable scale.

With the neutral field as indicated above, the zero of the movable scale should correspond closely with the zero of the vernier unless the zero point is out of adjustment.

If the observer desires to secure an exact adjustment of the zero of the scale, or in any case if the latter deviates more than one-half of a degree, the zero lines are made to coincide by moving the milled head and securing a neutral field at this point by means of the small key which comes with the instrument, and which fits into a nipple on the left hand side of F, the fixed quartz wedge of the compensating system. This nipple must not be confounded with a similar nipple on the right hand side of the analyzing prism, H, which it fits as well, but which must never be touched, as the adjustment of the instrument would be seriously disturbed by moving it. With the key on the proper nipple it is turned one way or the other until the field is neutral. Unless the deviation of the zero be greater than 0·5°, it will not be necessary to use the key, but only to note the amount of the deviation, and for this purpose the observer must not be content with a single setting, but must perform the operation five or six times, and take the mean of these different readings. If one or more of the readings show a deviation of more than 0·3° from the general average, they should be rejected as incorrect. Between each observation the eye should be allowed 10 to 20 seconds of rest.

The "setting" of the zero having been performed as above, the determination of the accurate adjustment of the instrument by means of the "control" quartz plates is proceeded with. Three such plates will be furnished with each polariscope, which have "sugar values" respectively approximating 80°, 90°, and 100°. These values may vary with the temperature, and tables are furnished with them which give their exact value at different temperatures, from 10° to 35° C.

One of these plates is placed in the instrument, and the field observed; it will be seen that the uniform appearance of the field is changed. The milled head is turned to the right until the exact point of neutrality is re-established, just as described above in setting the zero. The scale is read, the observation repeated, the reading taken again, and so on until five or six readings have been made. The average is taken, readings being rejected which show a divergence of more than 0·3, and the result corrected for the deviation of the zero point, if any was found, the deviation being added if it was to the left, and subtracted if to the right. If the adjustment of the instrument be correct, the result should be the value of the control plate used, as ascertained from the table, for the temperature of 20°. Each of the three plates is read in the instrument in this way. A variation of 0·3 from the established values may be allowed for errors of observation, temperature, etc., but in the hands of a careful observer a deviation greater than this with one of the three plates, after a careful setting of the zero, shows that the instrument is not accurately adjusted.

The complete verification of the accurate adjustment of the polariscope by means of three control plates, as given above, should be employed whenever it is set up for the first time by the officer using it, whenever it has sustained any serious shock or injury, and whenever it has been transported from one place to another. It should also be done at least once a week while the instrument is in active use.

After the complete verification has been performed as described, further checking of the instrument is done by means of one control plate alone, the one approximating 90°, and the setting of the zero point is dispensed with, the indication of the scale for sugar solutions being corrected by the amount of deviation shown in the reading of the 90° control plate from its established value as ascertained from the table, at the temperature of the room.

For example: A sugar solution polarizes 80·5; the control plate just before had given a polarization of 91·4, the temperature of the room during both observations being 25° C. According to the table the value of the control plate at 25° C. is 91·7; the reading is, therefore, 0·3 too low, and 0·3 is added to the reading of the sugar solution, making the corrected result 80·8. The temperature of the room should be ascertained from a standardized thermometer placed close to the instrument and in such a position as to be subject to the same conditions.

PREPARATION OF THE SUGAR SOLUTION FOR POLARIZATION.

If the sample is not entirely uniform it must be thoroughly mixed before weighing out, after all the lumps are broken up, best with a mortar and pestle. Then 26·048 grammes are weighed out on the balance in the tared German silver dish furnished for this purpose. Care must be taken that the operations of mixing and weighing out are not unduly prolonged, otherwise the sample may easily suffer considerable loss of moisture, especially in a warm room. The portion of sugar weighed out is washed by means of a jet from a wash bottle into a 100 c. c. flask, the dish being well rinsed three or four times and the rinsings added to the contents of the flask. The water used must be either distilled water or clear water which has been found to have no optical activity. After the dish has been thoroughly rinsed, enough water is added to bring the contents of the flask to about 80 c. c. and it is gently rotated until all the sugar has dissolved. The flask should be held by the neck with the thumb and finger, and the bulb not handled during this operation. Care must be taken that no particle of the sugar or solution is lost. To determine if all the sugar is dissolved, the flask is held above the level of the eye, in which position any undissolved crystals can be easily seen at the bottom. The character of the solution is now observed. If it be colorless or of a very light straw color, and not opalescent, so that it will give a clear transparent liquid on filtration through paper, the volume is made up directly with water to the 100 c. c. mark on the flask. Most sugar solutions, however, will require the addition of a clarifying or decolorizing agent in order to render them sufficiently clear and colorless to polarize. In such case, before making up to the mark, a saturated solution of subacetate of lead is added.

The quantity of this agent required will vary according to the quality of the sugar; for sugar which has been grained in the strike pan and washed in the centrifugals, from 3 to 15 drops will be required; for sugar grained in the strike pan but not well washed in the centrifugals, that is, sugar intended for refining purposes, from 15 to 30 drops will be required; for sugar not grained in the strike pan, that is, "wagon" or "string sugar," "second sugar," etc., from 1 to 3 c. c. will be required. After adding the solution of subacetate of lead the flask must be gently shaken, so as to mix it with the sugar solution. If the proper amount has been added, the precipitate will usually subside rapidly, but if not, the operator may judge of the completeness of the precipitation by holding the flask above the level of the eye and allowing an additional drop of subacetate of lead to flow down the side of the flask into the solution; if this drop leaves a clear track along the glass through the solution it indicates that the precipitation is complete; if, on the other hand, all traces of the drop are lost on entering the solution, it indicates that an additional small quantity of the subacetate of lead is required. The operator must learn by experience the point where the addition should cease; a decided excess of subacetate of lead solution should never be used.

The use of subacetate of lead should, in all cases, be followed by the addition of "alumina cream" (aluminic hydrate suspended in water)* in about double the volume of the subacetate solution used, for the purpose of completing the clarification, precipitating excess of lead, and facilitating filtration. In many cases of high grade sugars, especially beet sugars, the use of alumina alone will be sufficient for clarification without the previous addition of subacetate of lead.

The solution is now made up to the mark by the addition of distilled water in the following manner. The flask, grasped by the neck between the thumb and finger, is held before the operator in an upright position, so that the mark is at the level of the eye, and distilled water is added drop by drop from a siphon bottle or wash bottle, until the lowest point of the curve or meniscus formed by the surface of the liquid just touches the mark. If bubbles hinder the operation, they may be broken up by adding a single drop of ether, or a spray from an ether atomizer, before making up to the mark. The mouth of the flask is now tightly closed with the thumb, and the contents of the flask are thoroughly mixed by turning and shaking. The entire solution is now poured upon the filter, using for this purpose a funnel large enough to contain all the 100 c. c. at once, and a watch glass is placed over the funnel during filtration to prevent a concentration of the solution by evaporation.

The funnel and vessel used to receive the filtrate must be perfectly dry. The first portion of the filtrate, about 20 to 30 c. c., should be rejected entirely, as its concentration may be affected by a previous hygroscopic moisture content of the filter paper. It may also be necessary to return subsequent portions to the filter until the liquid passes through perfectly clear.

If a satisfactory clarification has not been obtained, the entire operation must be repeated, since only with solutions that are entirely clear and bright can accurate polarimetric observations be made.

When a sufficient quantity of the clear liquid has passed through the filter, the 200 mm. observation tube is filled with it. The 100 mm. tube should never be used except in rare cases, when notwithstanding all the means used to effect the proper decolorization of the solution, it is still too dark to polarize in the 200 mm. tube. In such cases the shorter tube may be used, and its reading multiplied by two. The zero deviation must then be determined and applied to the product. This will give the reading which would have been obtained if a 200 mm. tube could have been used, and it only remains to apply the correction determined by the use of the control plate as previously described.

Example:

Solution reads in 100 mm. tube	47·0
Multiplied by 2	2·0
Product	94·0
Zero reads plus 0·3	0·3
Solution would read in 200 mm. tube	93·7
Reading of control plate	90·4
Sugar value of control plate	90·5
Instrument too low by	0·1
Add 0·1 to	93·7
Correct polarization of solution	93·8

Before filling the tube it must either be thoroughly dried by pushing a plug of filter paper through it, or it must be rinsed several times with the solution itself. The cover glasses must also be clean and dry, and without serious defects or scratches. Unnecessary warming of the tube by the hand during filling should be avoided; it is closed at one end with the screw cap and cover glass, and grasped by the other end with the thumb and finger. The solution is poured into it until its curved surface projects slightly above the opening, the air bubbles allowed time to rise, and the cover glass pushed horizontally over the end of the tube in such a manner that the excess of liquid is carried over the side, leaving the cover glass exactly closing the tube with no air bubbles beneath it, and with no portion of the liquid upon its upper surface. If

* Prepared as follows: Shake up powdered commercial alum with water at ordinary temperature until a saturated solution is obtained. Set aside a little of the solution, and to the residue add ammonia, little by little, stirring between additions, until the mixture is alkaline to litmus paper. Then drop in additions of the portion left aside, until the mixture is just acid to litmus paper. By this procedure a cream of aluminum hydroxide is obtained suspended in a solution of ammonium sulphate, the presence of which is not at all detrimental for sugar work when added after subacetate of lead, the ammonium sulphate precipitating whatever excess of lead may be present.

this result is not attained, the operation must be repeated, the cover glass being rubbed clean and dry, and the solution again brought up over the end by adding a few more drops. The cover glass being in position, the tube is closed by screwing on the cap. The greatest care must be observed in screwing down the caps that they do not press too tightly upon the cover glasses; by such pressure the glasses themselves may become optically active, and cause erroneous readings when placed in the instrument. It should therefore be ascertained that the rubber washers are in position over the cover glasses, and the caps should be screwed on lightly. It must also be remembered that a cover glass, once compressed, may part with its acquired optical activity very slowly, and some time must be allowed to elapse before it is used again.

The polariscopic reading may now be taken, an observation on the 90° control plate having been made immediately before as previously described. Then without altering the position of the instrument relative to the light, or changing the character of the latter in any way, the tube filled with the sugar solution is substituted for the control plate. The telescope is adjusted, if necessary, so as to give a sharply defined field, which must appear round and clear. (This condition must be fulfilled before the observation is performed, as it is essential to accuracy.) The milled head is turned until the neutral point is found, and the reading is taken exactly as previously described, the operation repeated five or six times, the average taken with the rejection of aberrant readings, the average figure corrected for the deviation shown by the control observation from the sugar value of the control plate at the temperature of observation as given in the table, and the result taken as the polarization of the sugar. When a series of successive polarizations is made under the same conditions as regards temperature, position of the instrument with relation to the high intensity, of the light, etc., the control observation need not be made before each polarization, one such observation being sufficient for the entire series. The control must be repeated at least once an hour, however, and oftener when the operator has reason to think that any of the factors indicated above have been altered, for any such alteration of conditions may change the zero point of the instrument.

In the polarization of the quartz plates, as also in the polarization of very white sugars, difficulty may be experienced in obtaining a complete correspondence of both halves of the field. With a little practice this may be overcome and the neutral point found, but when it cannot, the ordinary telescope of the instrument may be replaced by another, which is furnished with the polariscope and which carries a yellow plate. This removes the difficulty and renders it possible, even for one not well accustomed to the instrument, to set it at the exact point of neutrality.

SUMMARIZED SOURCES OF ERROR.

The following principal sources of error must be especially guarded against:

1. Drying out of sample during weighing.
2. Excess of subacetate of lead solution in clarification.
3. Incomplete mixing of solution after making up to mark.
4. Imperfect clarification or filtration.
5. Concentration of solution by evaporation during filtration.
6. Undue compression of the cover glass.
7. Alteration of the temperature of room, position of instrument, or intensity of light while the observation or control observation is being performed.
8. Performances of polarization with a cloudy, dim, or not completely round or sharply defined field.

In closing this report the members of this commission hereby signify their intention to promote uniformity and accuracy by adopting and using the standards and general plan of procedure recommended in this report in the polarimetric determinations over which, in their respective branches of government work, they have control.

THE GRAND FALLS OF LABRADOR.

Hamilton Inlet, or Ionektoke, as the Esquimaux call it, is the outlet to the largest river on the Labrador Peninsula, and of great importance to commerce, Rigolet, the headquarters of the Hudson Bay Company in this region, being situated on its shores. This inlet is the great waterway to Central Labrador, extending into the interior for nearly 200 miles.

This immense basin is undoubtedly of glacial origin, evidences of ice erosion being plainly seen. It is divided into two general basins, connected by the "narrows," a small strait, through which the water rushes with frightful rapidity at each tide. Into the head of the inlet flows the Hamilton, or Grand River, an exploration of which, though attended with the greatest danger and privation, has enticed many men to these barren shores. Perhaps the most successful expedition thus far was that of Mr. Holme, an Englishman, who, in the summer of 1888, went as far as Lake Waminikapon, where, by failure of his provisions, he was obliged to turn back, leaving the main object of the trip, the discovery of the Grand Falls, wholly unaccomplished.

It has been left for Bowdoin College to accomplish the work left undone by Mr. Holme, to do honor to herself and her country by not only discovering, measuring, and photographing the falls, but making known the general features of the inland plateau, the geological structure of the continent, and the course of the river.

On Sunday, July 26, a party of the Bowdoin expedition, consisting of Messrs. Cary, Cole, Young, and Smith, equipped with two Rushton boats and a complement of provisions and instruments, left the schooner at the head of the inlet for a five weeks' trip into the interior, the ultimate object being the discovery of the Grand Falls. The mouth of the river, which is about one mile wide, is blockaded by immense sand bars, which have been laid down gradually by the erosive power of the river. These bars extend far out into Goose Bay, at the head of Lake Melville, and it is impossible to approach the shores except in a small boat. Twenty-five miles up the river are the first falls, a descent of the water of twenty-five feet, forming a beautiful sight. Here a cache of provisions was made, large enough to carry the party back to the appointed meeting place at Northwest River. The carry around the first falls is about one and a half miles in length, and very difficult on account of the steep sides of the river.

From the first falls to Gull Island Lake, forty miles above, the river is alternately quick and dead water. Part of it is very heavy rapids, over which it was necessary to track, and in some places to double the crews. Each boat had a tow line of fifty feet, and in tracking the end was taken ashore by one of the crew of two, while the boat was kept off the bank by the other man with an oar. At the Horseshoe Rapids, ten miles above Gull Island Lake, an accident happened which threatened to put a stop to further progress of the expedition. While tracking around a steep point in crossing these rapids the boat which Messrs. Cary and Smith were tracking was overturned, dumping barometer, shotgun, and ax into the river, together with nearly one-half the total amount of provisions. In the swift water of the rapids all these things were irrevocably lost, a very serious loss at this stage in the expedition. On this day so great was the force of the water that only one mile was made, and that only with the greatest difficulty.

Just above the mouth of the Nimpa River, which enters the Grand River twenty-five miles above Gull Island Lake, a second cache of provisions was made, holding enough to carry the party to their first cache at the first falls. One of the boats was now found to be leaking badly, and a stop was made to pitch the cracks and repair her, making necessary the loss of a few hours. From Nimpa River to the Mouni Rapids, at the entrance to Lake Waminikapon, the water was found to be fairly smooth, and good progress was made. The change in the scenery, too, is noticeable, becoming more magnificent and grand. The mountains, which are bolder and more barren, approach much nearer to each other on each side of the river, and at the base of these grim sentinels the river flows silvery and silently. The Mouni Rapids, through which the water passes from Lake Waminikapon, presented the next obstacle to further progress, but the swift water here was soon passed, and well repaid the traveler with the sight here presented almost unexpectedly to his view.

The lake was entered about 4 o'clock in the afternoon, and, as the narrow entrance was passed, the sun poured its full rich light on rocky mountains stretching as far away as the eye could reach, on each side of the lake, and terminating in rocky cliffs from 600 to 800 feet in perpendicular height, which formed the shores or confines of the lake. Across Lake Waminikapon, which is, more properly speaking, not a lake at all, but rather a widening of the river bed, the progress was very good, the water having no motion to retard the boats, and forty miles were made during the day.

Here a misfortune, which had been threatening for several days, came upon the party. Mr. Young's arm was so swollen, from the shoulder to finger tips, that he could scarcely move it, the pain being excessive. It had been brought on doubtless by cold and exposure. Seeing that he could be of no further use to the party, it was decided to divide forces, Mr. Smith returning with the sick man to Rigolet for medical assistance. The separation took place August 8, when the party had been on the river eleven days. The party were very sorry to return at this point, since from the best information which they could get in regard to the distance, the falls were but fifty miles above them. Under the circumstances, however, there was no help for it. So Smith and Young, bidding their friends good fortune, started on their return trip. The mouth of the river was reached in three days, a little less than one-third the time consumed in going up, and that, too, with only one man to handle the boat.

On the way down the river another party, composed of Messrs. Bryant and Kenaston of Philadelphia, was met, who were on the same business as the Bowdoin party, the discovery of the falls. Mr. Bryant handed to Mr. Young a twenty-five pound can of flour, which, he said, he had found in the whirlpool below the first falls. It had been in the boat which was overturned in the Horseshoe Rapids, and had made the journey to the first falls, a distance of over fifty miles, without denting or injuring the can in any way. It was a great relief to the Bryant party to learn the cause of the mishap, as they had feared a more serious calamity.

After the departure of the other two, Messrs. Cary and Cole encountered much rapid water, so that their progress was necessarily slow. On the third day, when they had proceeded sixty-five miles above Lake Waminikapon, and had seen no indications of any falls, the rapidity of the current forced them to leave the river and make any further progress on foot. The boat was cached at this point, together with all that was left of provisions and instruments except the compass and food for six days. They left just enough provisions to carry them to their last cache at Ninipi River, and hoped, by careful use of the remainder, to find the object of their search. If they had not enough provisions, then they must turn back, leaving reports of falls as destitute of confirmation as ever.

The land bordering the river at this point was heavily wooded, and in places where the river shore could not be followed on account of the cliffs, their progress was necessarily slow. Finding an elevation of land at no great distance from them, they ascended it for a general survey of the country. Far away in the distance could be seen the current of the Grand River flowing sluggishly but majestically on its course to the sea. Lakes on all sides were visible, most of them probably of glacial origin. Descending from this mountain, which the explorers christened Mount Bowdoin, a course was laid on the river bank, where camp was made that night. Being now somewhat weak from hard labor and insufficient food, their progress was slow through the thick wood, but on the next night camp was made on the edge of the plateau or table land of Labrador.

After proceeding a short distance on the next day, Aug. 13, a loud roar was heard in the distance, and a course was laid for the river at the nearest point. The river at this point, about one mile above the falls, was 500 yards wide, narrowing to fifty yards a short distance below, where great clouds of spray floating in the air warned the weary travelers that their object had been attained. Quickly they proceeded to the scene, and a magnificent sight burst upon their view.

Grand Falls, though not approaching the incredible height attributed to it by legendary accounts of the Indians, is a grand fall of water. Its total descent is accomplished in a series of falls aggregating nearly 500 feet. The greatest perpendicular descent is not over 200 feet. The half dozen falls between this grand descent and the bed of the river on the plateau vary from ten to twenty-five feet, adding to the majesty and grandeur of the scene. It was with great difficulty that the bottom of the falls was reached and a photograph of the scene taken.

After leaving the plateau and plunging over the falls, the waters enter an immense cañon or gorge, nearly 40 miles long and 300 yards wide, the perpendicular sides of which rise to a height of from 300 to 500 feet. The sides of this cañon show it to be hollowed out of solid Archæan rock. Through this cañon the water rushes with terrific rapidity, making passage by boat wholly impossible. Many erroneous stories have been told in regard to the height of these falls, all of them greatly exaggerating the descent of the water. The Indians of this locality of the tribe of the Nascopee or the race of Crees have long believed the falls to be haunted by an evil spirit, who punished with death any one who might dare to look upon them. The height of land or plateau which constitutes the interior of the Labrador peninsula is from 2,000 to 2,500 feet above the sea level, fairly heavily wooded with spruce, fir, hackmatack, and birch, and not at all the desolate waste it has been pictured by many writers. The barrenness of Labrador is confined to the coast, and one cannot enter the interior in any direction without being struck by the latent possibilities of the peninsula were it not for the abundance of flies and mosquitoes. Their greed is insatiable, and at times the two men were weakened from the loss of blood occasioned by these insects.

The object of the expedition being attained, the return trip was begun, and the sight of the cached boat and provisions eagerly watched for. On Aug. 15 the camp was sighted, but to their horror they saw smoke issuing from the spot. It at once flashed upon their minds what had taken place, and when they arrived they found that their fears had been all too truly realized. Charred remains of the boat, a burned octant, and a few unexploded cartridges were all that remained of the meager outfit upon which they depended to take them to the mouth of the river, a distance of over 250 miles. The camp fire, not having been completely extinguished, had burned the boat and destroyed all their provisions.

It was truly a hard outlook for them, but no time must be lost if provisions were to be obtained. Hastily a raft was constructed, the logs being bound together with spruce roots. In this way, by alternately walking and rafting, the mouth of the river was reached Aug. 29. On the way down the river five rafts had been made and abandoned. The only weapon was a small pocket revolver, and with the products of this weapon, mostly red squirrels and a few fish, they lived until they reached the different caches. Many a meal was made of one red squirrel divided between them, and upon such food they were compelled to make the best time possible. On the way up the river the shoes of one of the party had given wholly out, and he was obliged to make a rude pair of slippers from the back of a leather pack. With torn clothes and hungry bodies they presented a hard sight indeed when they joined their friends at Rigolet on the 1st of September. The party composed of Messrs. Bryant and Kenaston was passed by Cary and Cole while on the way down, but was not seen. Probably this occurred on Lake Waminikapon, the width of the lake preventing one party from seeing the other. It seemed a waste of time and energy that two expeditions in the same summer should be sent upon the same object, but neither party knew of the intention of the other until it was too late to turn back.

Grand River has long been a highway for the dependents of the Hudson Bay Company. The company formerly had a post on Lake Waminikapon, and another, called Height of Land, on the plateau. Provisions were carried to these posts, and furs brought from them by way of Grand River, the parties proceeding as far as the lake, and then, leaving Grand River some distance below the cañon, no longer being able to follow it on account of the swiftness of the water, they carried their canoes across the land to a chain of lakes connecting with the post. This station has been given up many years, and the river is used now chiefly be Indians and hunters in the winter.

It has long been known that Hamilton Inlet was of glacial origin, the immense basin hollowed out by this erosive agent being 150 miles in length. How much further this immense valley extended has never been known. Mr. Cary says that the same basin which forms Hamilton Inlet and enters Lake Melville, the two being connected by twelve miles of narrows, extends up the Grand River Valley as far as Gull Island Lake, the whole forming one grand glacial record. From Lake Melville to Gull Island the bed was being gradually filled in by the deposits of the river, but the contour of the basin is the same here as below. The bed of the country here is Archæan rock, and many beautiful specimens of labradorite dot the shores. In the distance the grim peaks of the Mealy Mountains stand out in bold relief against the sky.

The country about this interior basin is heavily wooded, and spars of 75 feet can be obtained in generous numbers. Were it not for the native inhabitants, mosquitoes, and flies, the interior would present conditions charming enough to tempt any lover of nature. It is the abundance of these invincible foes which make interior life a burden and almost an impossibility. To these inhabitants alone Grand Falls has ceased to chant its melodious tune. Hereafter its melodious ripple will be heard by Bowdoin College, which, in the name of its explorers, Cary and Cole, claims the honor of its discovery.—*New York Times.*

ANTS.

By Ruth Ward Kahn.

Astronomy has made us all familiar with the conception of the world over our heads. We no longer speculate with Epicurus and Anaxagoras whether the sun may be as large as a quoit, or even as large as Peloponnesus. We are satisfied that the greater and the lesser lights are worlds, some of them greatly exceeding our own in magnitude.

In a little poem of Dante Rossetti's, he describes a mood of violent grief in which, sitting with his head

bowed between his knees, he unconsciously eyes the wood spurge growing at his feet, till from those terrible moments he carries away the one trivial fact cut into his brain for all time, that "the wood spurge has a cup of three." In some such mood of troubled thought, flung perhaps full length on the turf, have we not as unconsciously and intently watched a little ant, trudging across our prostrate form, intent upon its glorious polity: a creature to which we, with our great spiritual world of thought and emotion and will, have no existence except as a sudden and inconvenient upheaval of parti-colored earth to be scaled, of unknown geological formation, but wholly worthless as having no bearing upon the one great end of their life—the care of larvæ.

If we hold with Mr. Wallace that the chief difference between man and the lower animals is that of kind and not of degree—that man is possessed of an intelligent will that appoints its own ends, of a conscience that imposes upon him a "categorical imperative," of spiritual faculties that apprehend and worship the invisible—yet we must admit that his lower animal nature, which forms, as it were, the platform of the spiritual, is built up of lower organisms.

If we hold with Professor Allman that thought, will, and conscience, though only manifesting themselves through the medium of cerebral protoplasm, are not its properties any more than the invisible earth elements which lie beyond the violet are the property of the medium which, by altering their refrangibility, makes them its own—then the study of the exact nature and properties of the transmitting medium is equally necessary. Indeed, the whole position can only be finally established of defining experimentally the necessary limitation of the medium, and proving the inefficiency of the lower data to account with the higher.

It is these considerations of the wider issues that give such a peculiar interest to the patient observations which have recently been brought to bear upon the habits of the social insects, especially of ants, which, living in communities, present so many of the conditions of human life, and the development of the "tribal self" from these conditions, to which Professor Clifford attributed the genesis of moral sense.

In order to pass in review these interesting observations and bring out their significance, I must go over ground which is doubtless familiar to most of my readers.

The winged ants, which often excite surprise, are simply the virgin queens and the males. They are entirely dependent upon the workers, and are reared in the same nest. September is the month usually selected as the marriage season, and in the early twilight of a warm day the air will be dark with the winged lovers. After the wedding trip the female tears off her wings—partly by pulling, but mostly by contortions of her body—for her life under ground would render wings not only unnecessary, but cumbersome; while the male is not exposed to the danger of being eaten by his cannibal spouse, as among spiders, nor to be set upon and assassinated by infuriated spinsters, as among bees, but drags out a precarious existence for a few days, and then either dies or is devoured by insectivorous insects. There is reason to believe that some females are fertilized before leaving the nest. I have observed flights of the common *Formica rufa*, in which the females flew away solitary and to great distances before they descended. In such cases it is certain that they were fertilized before their flight.

When a fertilized queen starts a colony it proceeds much in this way: When a shaft has been sunk deep enough to insure safety, or a sheltered position secured underneath the trunk of a tree or a stone, the queen in due time deposits her first eggs, which are carefully reared and nourished. The first brood consists wholly of workers, and numbers between twenty-five and forty in some species, but is smaller in others. The mother ant seeks food for herself and her young till the initial brood are matured, when they take up the burden of life, supply the rapidly increasing family with food, as well as the mother ant, enlarge the quarters, share in the necessary duties, and, in short, become the *real* workers of the nest before they are scarcely out of the shell. The mother ant is seldom allowed to peer beyond her dark quarters, and then only in company with her body guard. She is fed and cared for by the workers, and she in turn assists them in the rearing of the young, and has even been known to give her strength for the extension of the formicary grounds. Several queens often exist in one nest, and I have seen workers drag newly fertilized queens into a formicary to enlarge their resources. As needs be, the quantity of eggs laid is very great, for the loss of life in the ranks of the workers is very large; few survive the season of their hatching, although queens have been known to live eight years. (Lubbock.)

The ant life has four well marked periods: First, the egg; second, the grub or larva; third, the chrysalis or pupa; fourth, the imago, or perfect insect. The eggs are small, ovate, yellowish white objects, which hatch in about fifteen to thirty days. The larvæ are small legless grubs, quite large at the apex of the abdomen and tapering toward the head. Both eggs and pupa are incessantly watched and tended, licked and fed, and carried to a place of safety in time of danger. The larvæ are ingeniously sorted as regards age and size, and are never mixed. The larvæ period generally extends through a month, although often much longer, and in most species when the larvæ pass into pupæ they spin a cocoon of white or straw color, looking much like a shining pebble. Other larvæ do not spin a cocoon, but spend the pupal state naked. When they mature they are carefully assisted from their shells by the workers, which also assist in unfolding and smoothing out the legs. The whole life of the formicary centers upon the young, which proves they have reached a degree of civilization unknown even in some forms of higher life.

It is curious that, notwithstanding the labor of so many excellent observers, and though ants swarm in every field and wood, we should find so much difficulty in the history of these insects, and that so much obscurity should rest upon some of their habits. Forel and Ebrard, after repeated observations, maintain that in no single instance has an isolated female been known to bring her young to maturity. This is in direct contradiction to Lubbock's theory, who repeatedly tried introducing a new fertile queen into another nest of *Lasius flavus*, and always with the result that the workers became very excited and killed her, even though in one case the nest was without a queen. Of the other kinds, he isolated two pairs of *Myrmica ruginodis*, and, though the males died, the queens lived and brought their offspring to perfection; and nearly a year after their captivity, Sir John Lubbock watched the first young workers carrying the larvæ about, thereby proving the accuracy of Huber's statement, with some species at least. In spite of this convincing testimony, Lepeletier St. Fargeau is of the opinion that the nests originate with a solitary queen, as was first given.

The ants indigenous to Leadville, besides feeding on small flies, insects, and caterpillars—the carcasses of which they may be seen dragging to their nests—show the greatest avidity for sweet liquids. They are capable of absorbing large quantities, which they disgorge into the mouths of their companions. In winter time, when the ants are nearly torpid and do not require much nourishment, two or three ants told off as foragers are sufficient to provide for the whole nest. We all know how ants keep their herds in the shape of aphides, or ant cows, which supply them with the sweet liquid they exude. I have often observed an ant gently stroking the back of an aphide with its antennæ to coax it to give down its sweet fluid, much in the same way as a dairy maid would induce a cow to give down its milk by a gentle manipulation of its udders. Some species, principally the masons and miners, remove their aphides to plants in the immediate vicinity of their nest, or even introduce them into the ant home. In the interior of most nests is also found the small blind beetle (*Claviger*) glistening, and of a uniform red, its mouth of so singular a conformation that it is incapable of feeding itself. The ants carefully feed these poor dependent creatures, and in turn lick the sweet liquid which they secrete and exude. These little *Coleoptera* are only found in the nests of some species; when introduced into the nests of others they excite great bewilderment, and, after having been carefully turned over and examined, are killed in a short time as a useless commodity. Another active species of *Coleoptera*, of the family *Staphylini*, is also found in ant nests. I have discovered one in the nest of *Formica rufa* in the Jewish cemetery in Leadville. Furnished with wings, it does not remain in the nest, but is forced to return thither by the strange incapacity to feed itself. Like the *Claviger*, it repays its kind nurses by the sweet liquid it exudes, and which is retained by a tuft of hair on either side of the abdomen beneath the wings, which the creature lifts in order that the ant may get at its honeyed recompense. Such mutual services between creatures in no way allied is a most curious fact in the animal world.—*Popular Science News.*

A GEM-BEARING GRANITE VEIN IN WESTERN CONNECTICUT.

By L. P. GRATACAP.

IN the county of Litchfield, Conn., in the midst of some of the most attractive hill country of that region, a very striking mineral fissure has been opened by Mr. S. L. Wilson, which, in both its scientific and commercial aspects, is equally important and interesting. It is a broad crevice, widened at the point of excavation into something like a pocket and filled, between its inclosing walls of gneiss, with a granitic mass whose elements have crystallized separately, so that an almost complete mineralogical separation has been effected of quartz, mica, and feldspar, while associated aggregates, as beryl and garnet, have formed under conditions that make them valuable gem fabrics.

The vein has a strike south of west and north of east and a distinct dip northwest, by which it is brought below the gneiss rock, which forms an overhanging wall, on the northerly side of the granitic mass, while on the southerly edge the same gneiss rock makes an almost vertical foot wall, and exhibits a sharp surface of demarkation and contact. The rock has been worked as an open cut through short lateral "plunges," or tunnels have been used for purposes of exploration in the upper part of its extent. Its greatest width appears to be fifty-one feet, and the present exposure of its length three hundred. It undergoes compression at its upper end, and its complete extinction upon the surface of the country at that point seems probable. At its lower end at the foot of the slope wherein the whole mass appears, it reveals considerable development, and affords further opportunities for examination, and, possibly, profitable investment. It has been formed by a powerful thrust coincident with the crumpling of the entire region, whereby deeply seated beds have become liquefied, and the magma either forced outward through a logitudinal vent or brought to the surface by a process of progressive fusion as the heated complex rose through superincumbent strata dissipated by its entrance and contributing their substance to its contents. The present exposure of the vein has been produced by denudation, as the coarsely crystalline and dismembered condition of the granite, with its large individuals of garnet and beryl, and the dense, glassy texture of the latter, indicate a process of slow cooling and complete separation, and for this result the congealing magma must necessarily have been sealed in by strata through which its heat was disseminated slowly.

For upon the most cursory inspection of the vein, the eye is arrested at once by the large masses of crystalline orthoclase, the heavy beds of a gray, brecciated quartz and the zones and columns of large leaved mica. It was to secure the latter that Mr. Wilson first exploited this locality, and only latterly have the more precious contents of the vein imparted to it a new and more significant character. The mica, called by Mr. Atwood, the superintendent of the work, "book mica," occurs in thick crystals, ranged heterogeneously together in stringers and "chimneys," and brilliantly reflecting the sunlight from their diversely commingled laminæ. This mica yields stove sheets of about two to three by four or five inches, and is of an excellent, transparent quality. It seems to be a true muscovite, and is seldom marred by magnetic markings or crystalline inclusions that would interfere with its industrial use. Seams of decomposition occur, and a yellowish scaly product, composed of hydrated mica flakes, fills them. The mica does not everywhere present this coarsely crystalline appearance, but in flexures and lines of union with the quartz and orthoclase is degraded to a mica schist upon whose surfaces appear uranates of lime and copper (autunite and torbernite), and in which are inclosed garnet crystals of considerable size and beauty. The enormous masses of clean feldspar made partially "graphic" by quartz inclosures are a conspicuous feature of the mine. In one part of the mine, wooden props support an overhanging ledge almost entirely composed of feldspar, which underneath passes into the gray brecciated quartz, which again grades into a white, more compact quartz rock. It is in this gray brecciated quartz that the beryls are found. These beautiful stones vary extremely in quality and color. Many of the large crystals are opaque, extensively fractured, and irregular in grain, but are found to inclose, especially at their centers, cores of gem-making material.

The colors of the beryls grade from an almost colorless mineral (goshenite) though faintly green, with blue reflections, yellowish green of a peculiar oily liquidity (davidsonite), to honey yellows which form the so-called "golden beryls" of the trade, and which have a considerable value. These stones have a hardness of 8, and when cut display much brilliancy. Many assume the true aquamarine tints, and others seem to be almost identical with the "Diamond of the Rhine," which as early as the end of the fifteenth century was used as a "fraudulent substitute for the true diamond" (King). Few, very few, belong to the blue grades, and the best of these cannot compare with those from Royalston, Mass. Those of amber and honey shades are beautiful objects, and under artificial light have a fascination far exceeding the olivine or chrysoberyl. These are not as frequent as the paler varieties, but when found excite the admiration of visitor and expert. It seems hardly probable that any true emeralds will be uncovered and the yellow beryls may not increase in number. Their use in the arts will be improved by combining them with other stones and by preparing the larger specimens for single stone rings.

Very effective combinations of the aquamarine and blue species with the yellow may be recommended. Tourmaline appears in some quantity, forming almost a schist at some points, but no specimens of any value have been extracted, the color being uniformly black. The garnets are large trapezohedral-faced crystals of an intense color, but penetrated with rifts and flaws. Many, no doubt, will afford serviceable gem material, but their resources have not yet been tested by the lapidary.

While granite considered as a building stone presents a complex of quartz, mica, and feldspar so confusedly intercrystallized as to make a homogeneous composite, in the present mass, like the larger and similar developments in North Carolina, these elements have excluded each other in their crystallization, and are found as three separate groups only sparingly intermingled. The proportions of the constituent minerals which form granite, according to Prof. Phillips, are twenty parts of potash feldspar (orthoclase), five parts of quartz, and two parts of potash mica (muscovite), and a survey of Mr. Wilson's quarry exhibits these approximate relations with surprising force.

There can be but little doubt that this vein is a capital example of hydrothermal fusion, whereby in original gneissic strata, at a moderate temperature and considerable depth, through the action of contained water, with the physical accompaniment of plication, a solution of the country rock has been accomplished. And the cooling and recrystallization has gone on so slowly that the elements of granite have preserved a physical isolation, while the associated silicates formed in the midst of this magma have attained a supremely close and compact texture, owing to the favorable conditions of slow growth giving them gem consistencies. The further development of the vein may reveal interesting facts, and especially the following downward of the rock mass, which we suspect will contract into a narrower vein. At present the order of crystallization and separation of the mineralogical units seems to have been feldspar, mica, garnet, beryl, quartz.

In the artificial preparation of crystals it is invariably found that perfect and symmetrical crystals, and crystals of large size, are produced by slow, undisturbed cooling of solutions; the quiet accretion permits complete molecular freedom and the crystal is built up with precision. Nor is this all. In mixtures of chemical compounds it is presumable that the separate factors will disengage themselves from each other more and more completely, and form in purer masses as the congelation is slowly carried on. A sort of concretionary affinity comes into play, and the different chemical units congregate together. At least such has been the case in the granitic magma of which Mr. Wilson now possesses the solidified results. The feldspar, the quartz, the mica, have approximately excluded each other, and appear side by side in unmixed purity. And does it not seem probable that this deliberate process of solidification has produced in the beryls, found in the center of the vein at the points of slowest radiation, the glassy gem texture which now makes them available for the purposes of art and decoration?

THE STUDY OF MANKIND.

PROFESSOR MAX MULLER, who presided over the Anthropological Section of the British Association, said that if one tried to recall what anthropology was in 1847, and then considered what it was now, its progress seemed most marvelous. These last fifty years had been an age of discovery in Africa, Central Asia, America, Polynesia, and Australia, such as could hardly be matched in any previous century. But what seemed to him even more important than the mere increase of material was the new spirit in which anthropology had been studied during the last generation. He did not depreciate the labors of so-called dilettanti, who were after all lovers of knowledge, and in a study such as that of anthropology, the labors of these volunteers, or franc-tireurs, had often proved most valuable. But the study of man in every part of the world had ceased to be a subject for curiosity only. It had been raised to the dignity and also the responsibility of a real science, and was now guided by principles as strict and rigorous as any other science. Many theories which were very popular fifty years ago were now completely exploded; nay, some of the very principles by which the science was then guided had

been discarded. Among all serious students, whether physiologists or philologists, it was by this time recognized that the divorce between ethnology and philology, granted if only for incompatibility of temper, had been productive of nothing but good.

CLASSIFICATION.

Instead of attempting to classify mankind as a whole, students were now engaged in classifying skulls, hair, teeth, and skin. Many solid results had been secured by these special researches; but as yet, no two classifications, based on these characteristics, had been made to run parallel. The most natural classification was, no doubt, that according to the color of the skin. This gave us a black, a brown, a yellow, a red, and a white race, with several subdivisions. This classification had often been despised as unscientific; but might still turn out far more valuable than at present supposed. The next classification was that by the color of the eyes, as black, brown, hazel, gray, and blue. This subject had also attracted much attention of late, and, within certain limits, the results have proved very valuable. The most favorite classification, however, had always been that according to the skulls. The skull, as the shell of the brain, had by many students been supposed to betray something of the spiritual essence of man; and who could doubt that the general features of the skull, if taken in large averages, did correspond to the general features of human character? We had only to look around to see men with heads like a cannon ball and others with heads like a hawk. This distinction had formed the foundation for a more scientific classification into brachycephalic, dolichocephalic, and mesocephalic skulls. If we examined any large collection of skulls we had not much difficulty in arranging them under these three classes; but if, after we had done this, we looked at the nationality of each skull, we found the most hopeless confusion. Pruner Vey, as Peschel told us in his "Volkerkunde," had observed brachycephalic and dolichocephalic skulls in children born of the same mother; and if we consider how many women had been carried away into captivity by Mongolians in their inroads into China, India, and Germany, we could not feel surprised if we found some long heads among the round heads of those Central Asiatic hordes.

DIFFERENCES IN SKULLS.

Only we must not adopt the easy expedient of certain anthropologists who, when they found dolichocephalic and brachycephalic skulls in the same tomb, at once jump to the conclusion that they must have belonged to two different races. When, for instance, two dolichocephalic and three brachycephalic skulls were discovered in the same tomb at Alexanderpol, we were told at once that this proved nothing as to the simultaneous occurrence of different skulls in the same family; nay, that it proved the very contrary of what it might seem to prove. It was clear, we were assured, that the two dolichocephalic skulls belonged to Aryan chiefs and the three brachycephalic skulls to their non-Aryan slaves, who were killed and buried with their masters, according to a custom well known to Herodotus. This sounded very learned, but was it really quite straightforward? Besides the general division of skulls into dolichocephalic, brachycephalic, and mesocephalic, other divisions had been undertaken, according to the height of the skull, and again according to the maxillary and the facial angles. This latter division gave us orthognatic, prognathic, and mesognathic skulls. Lastly, according to the peculiar character of the hair, we might distinguish two great divisions, the people with woolly hair (Ulotriches) and people with smooth hair (Lissotriches). The former were subdivided into Lophocomi, people with tufts of hair, and Eriocomi, or people with fleecy hair. The latter were divided into Euthycomi, straight haired, and Euplocomi, wavy haired. It had been shown that these peculiarities of the hair depended on the peculiar form of the hair tubes, which in cross sections were found to be either round or elongated in different ways. All these classifications, to which several more might be added, those according to the orbits of the eyes, the outlines of the nose, and the width of the pelvis, were by themselves extremely useful. But few of them only, if any, ran strictly parallel. Now let them consider whether there could be any organic connection between the shape of the skull, the facial angle, the conformation of the hair, or the color of the skin on one side, and what we called the great families of language on the other.

CONNECTION OF LANGUAGE AND PHYSICAL CONFORMATION.

That we spoke at all might rightly be called a work of nature, *opera naturale*, as Dante said long ago; but that we spoke thus or thus, *cosi o cosi*, that, as the same Dante said, depended on our pleasure—that was our work. To imagine, therefore, that as a matter of necessity, or as a matter of fact, dolichocephalic skulls had anything to do with Aryan, mesophalic with Semitic, or brachycephalic with Turanian speech, was nothing but the wildest random thought. It could convey no rational meaning whatever; we might as well say that all painters were dolichocephalic, and all musicians brachycephalic, or that all lophocomic tribes worked in gold, and all lisocomic tribes in silver. If anything must be ascribed to prehistoric times, surely the differentiation of the human skull, the human hair and the human skin would have to be ascribed to that distant period. No one, he believed, had ever maintained that a mesocephalic skull was split or differentiated into a dolichocephalic and a brachycephalic variety in the bright sunshine of history. Nevertheless, he had felt for years that knowledge of languages must be considered in future as a *sine qua non* for every anthropologist. How few of the books in which we trusted with regard to the characteristic peculiarities of savage races had been written by men who had lived among them for ten or twenty years, and who had learned their languages till they could speak them as well as the natives themselves. It was no excuse to say that any traveler who had eyes to see and ears to hear could form a correct estimate of the doings and sayings of savage tribes.

TRAVELERS' IMPRESSIONS.

It was not so, as anthropologists knew from sad experience. Suppose a traveler came to a camp where he saw thousands of men and women dancing round the image of a young bull. Suppose that the dancers were all stark naked, that after a time they began to fight, and that at the end of their orgies there were three thousand corpses lying about weltering in their blood. Would not a casual traveler have described such savages as worse than the negroes of Dahomey? Yet these savages were really the Jews, the chosen people of God. The image was the golden calf, the priest was Aaron, and the chief who ordered the massacre was Moses. We might read the 32d chapter of Exodus in a very different sense. A traveler who could have conversed with Aaron and Moses might have understood the causes of the revolt and the necessity of the massacre. But without this power of interrogation and mutual explanation, no travelers, however graphic and amusing their stories might be, could be trusted; no statements of theirs could be used by the anthropologist for truly scientific purposes. If anthropology was to maintain its high position as a real science, its alliance with linguistic studies could not be too close. Its weakest points had always been those where it trusted to the statements of authorities ignorant of language and of the science of language. Its greatest triumphs had been achieved by men such as Dr. Hahn, Bishops Callaway and Colenso, Dr. W. Gill and last, not least, Mr. Man, who had combined the minute accuracy of the scholar with the comprehensive grasp of the anthropologist, and were thus enabled to use the key of language to unlock the perplexities of savage customs, savage laws and legends, and, particularly, of savage religions and mythologies. If this alliance between anthropology and philology became real, then, and then only, might we hope to see Bunsen's prophecy fulfilled, that anthropology would become the highest branch of that science for which the British Association was instituted.

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